

# Light and Lighting

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One Shilling

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## Lighting Contractors

LAST month our Notes and News included a paragraph referring to the apparent lack of interest of many electrical contractors in the science and art of lighting, despite the fact that they undertake the installation of lighting. Our contributor "Lumeritas" had, also, a sorry account to give upon the same theme, and we make no apology for returning to it here since we feel quite strongly that the consumer has a right to expect lighting contractors to be much better versed in the subject than most of them are. It may be too much to expect that all lighting contractors will seek to qualify for inclusion in the I.E.S. Register of Lighting Engineers, or to employ among their staff someone who has obtained registration, but it is surely not too much to expect that a majority of them should avail themselves of technical periodicals to enlarge their knowledge and to keep abreast of new developments. As to this, our own Journal is, of course, the only one in this country specifically devoted to lighting. It cannot be for economic reasons that all lighting contractors do not see LIGHT AND LIGHTING, for it costs but a halfpenny a day!

# Notes and News

## New I.E.S. President

In October a new I.E.S. session begins and changes in the officers of the Society take place. The present President, Dr. J. N. Aldington, retires and the new President, Mr. L. J. Davies takes office for the ensuing year.

Well known as Director of Research of the British Thomson-Houston Company, Mr. Davies joined that organisation in 1924 when he left Oxford. After spending some time on valve research his interests widened and he rose to be head of the lamp and vacuum physics section. He joined the board as Director of Research and Education in 1946. The Research Laboratory covers a wide field and has interests in all electrical engineering as well as in lamps and lighting. In addition to directing the company's research work Mr. Davies is also responsible for the educational policy of the company and for the training of its 1,300 apprentices. For many years Mr. Davies was actively concerned with lamp design and recently has been particularly interested in the applications of fluorescent lamps. He has travelled widely in connection with lighting matters and has published a number of papers.

The fact that the new President has such a wide experience both in and beyond the field of lighting should be a great asset to the Society. We extend our congratulations to Mr. Davies and wish him a most successful year of office.

Mr. Davies will deliver his Presidential Address and be inducted as President at the opening meeting of the I.E.S., which

will take place at the Royal Society of Arts, John Adam-street, at 6 p.m. on Tuesday, October 10.

## Southampton Terminal

Elsewhere in this issue we give a description of the lighting in the new Ocean Terminal at Southampton Docks which was recently opened by the Prime Minister and which is now in regular use by visitors from overseas passing through that port.

Though certain aspects of the building have been criticised, particularly by the architectural profession, the impression it must make upon those using it upon disembarkation cannot be other than the most favourable. The shape and size of the building was more or less determined by its position on the quay and the nature of the job it has to perform, i.e., to handle and to pass through the various formalities

the thousands of passengers embarking or disembarking with their attendant tons of luggage and to get them from ship to train or vice versa as quickly as possible. The building is therefore essentially functional and we are sure it will prove to be very efficient.

From ship to train the building is very well lighted; decorative lighting from concealed sources in the waiting halls is very effective whilst the customs halls are so well lighted that it will be difficult for anyone to hide anything in the shadows of his bag.

Remembering the old sheds at Southampton and the facilities at other ports, both in this country and abroad,



MR. L. J. DAVIES

we have reason to be proud of the new terminal.

### Hotel Lighting

Quite a large part of this issue is given to the subject of hotel and restaurant lighting, a subject which, as pointed out by a contributor a few months ago, should receive some attention before the anticipated influx of visitors from overseas to the Festival of Britain next year.

The articles which follow show that our lighting engineers and architects are not lacking in ideas for making the public rooms of our hotels and restaurants attractive but unfortunately there is little mention of lighting in the private rooms of hotels. (Perhaps these rooms have too much in common with similar rooms in private houses and we notice that no one is very anxious to say how one's home should be lighted.)

Maybe we are just unlucky or perhaps we can't afford to pay enough but too often when we have to stay at an hotel we find the lighting in our room quite inadequate. The inevitable central pendant is usually screened so that no light can fall where it is required and one discovers on trying to read in bed that the whole light output of the lamp (clear) is cunningly directed into one's eyes. If there is a bedside lamp it either doesn't work or is otherwise ineffective. Our pet aversion is the box-like contraption hooked on to the bed head with a couple of pieces of bent wire, screened on all sides except the bottom with a semi-opaque material (transmission factor about 2 per cent.), the object of leaving the bottom uncovered presumably being to light the back of one's neck.

We know there are plenty of hotels where such conditions do not and could not exist but not all of our overseas visitors are millionaires and quite a few of them prefer to find reasonably cheap accommodation. During 1951 no doubt many of them will be glad to take what they can get but even so this is no reason why they should have to put up with poor lighting when it is so easy to make a room bright and cheerful with quite

small adjustments to the lighting. Even if every hotelier in the country were to read these comments we wouldn't expect them to order new fittings for all their rooms; but it might be helpful if someone pointed out to the hoteliers that good fittings pay in the long run and are frequently no more expensive than poor ones. Some hoteliers no doubt already appreciate this, and we hope that before long it will be generally accepted by all that good lighting is not necessarily expensive.

### Street Lighting Code of Practice

The draft code of practice for street lighting prepared by a joint committee of the B.S.I. and I.E.E. has now been issued for comment. Street lighting engineers throughout the country have long waited for this document and will study it with great interest.

The document is based on the recommendations of the Departmental Committee on Street Lighting bearing in mind developments which have taken place since 1937. It deals only with the lighting of traffic routes (Group A); Group B installations will probably be dealt with in a further document in due course.

The main purpose of the code is to set out the factors to be considered when designing street lighting installations, and its recommendations are intended to serve as a guide to the lighting engineer.

The code is divided into sections dealing with types of installations, mounting height, arrangement of sources, spacing, overhang, light distribution, glare, the lighting of straight roads, bends, gradients, roundabouts, and dual-carriageways. It is well illustrated by simple line diagrams.

We hope to deal more fully with the recommendations of the draft code in our next issue. In the meantime the draft has been the subject of a paper by Dr. J. W. T. Walsh (chairman of the committee responsible for its preparation) at the A.P.L.E. Conference, which will also be reported in our next issue.



*An impressive view of Edinburgh Castle floodlit during the Festival.*

# Hotel and Restaurant Lighting

By K. S. MORRIS, M.S.I.A.

**Our impressions of an hotel or restaurant can be largely influenced, consciously or otherwise, by the lighting arrangements. Different rooms need different treatment; this article deals with some of the main points to be considered.**

The Festival of Britain steadily approaches and one hopes that Britain's hôteliers and restaurateurs will consider in good time the advantages of a new and attractive lighting scheme for the whole, or perhaps some part, of their building. Hotels and restaurants are certainly one of those industries which are very much based on what one might term "the home trade." None the less, every summer, and particularly as next summer approaches, they take on a new aspect. This is, of course, the important matter of catering for visitors to our country, many of whom will come here with very definite ideas of what a hotel or restaurant should be, based on what they are used to in their own country.

It is often a source of wonder that so many in charge of such buildings do not yet seem to have realised what a wonderful difference appropriate decorative lighting will make to their guests, and, need one add, to their turnover. Very often the food will be exquisite, the furniture delightful and the beds most comfortable, yet the lighting still occupies the humble position of Cinderella. It is odd that no one appears to cavil at spending quite a large sum of money to cover the floor of a room with a most resplendent carpet, while the opposite surface carries only one or two very humble lighting fittings that have long since seen their day.

Those of us who are concerned with decorative lighting are full of the most delightful suggestions for various lighting

schemes but, unfortunately, the present times only permit, in general, of relighting schemes. As is known, the most charming results usually can only be obtained if the lighting is incorporated in a new building as part of the whole conception, or in a major reconstruction. Nowadays, such instances are very rare, and so, in the vast majority of cases, the lighting engineer has to work within the limits of the existing and, perhaps, old-fashioned building which confronts him. None the less, it is wonderful what can be done if only the client will come forward in the early stages of any project so that decorations, relighting and, possibly, even small structural modifications can be considered as a whole. Only in this way can a satisfactory installation emerge.

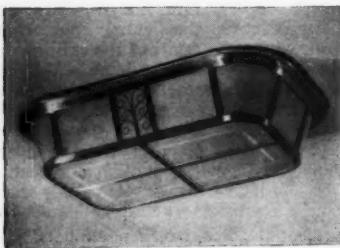
Incidentally, it is worth pointing out that lighting fittings and apparatus of all types can be provided without licence. This, of course, means that a clever scheme of redecoration and relighting can quite change the appearance of an interior without the necessity of any licences whatsoever, providing, of course, certain simple conditions are adhered to, and provided the rewiring and redecoration are within the permitted figures. Outside of those, of course, the necessary licence must be obtained for these two items.

Nowadays lighting covers such a wide field that the number of ways of lighting a room is almost infinite, and the real governing factors are the client's taste, bearing in mind the style of the room, together with the amount of money available. Naturally the simplest though often very decorative solution is using pendant or ceiling fittings as appropriate. The popularity of the hot and the cold cathode light sources has, since the war, even further increased the popularity of the various forms of indirect lighting, and indirect cornice lighting is now a very firm favourite in the public rooms of hotels and restaurants. However, please do not forget that both direct and indirect light-

ing are vastly improved in general appearance by the use of judiciously chosen wall brackets, together with perhaps one or two table and floor standards. In general, these will not give much additional light, nor are they expected to, but they will provide just that touch of added interest in the room and prevent a flat appearance.

Below is a typical pendant fitting which would look well in many public rooms. For rooms with a low ceiling the other fitting depicted below would afford a pleasing solution. These two fittings are, of course, merely representative of their types, and there are many other interesting designs of fittings both smaller and larger. There are naturally many rooms where the decorative feeling is of a period flavour. Here, one would suggest the use of chandeliers of the appropriate period. There are also cer-

several disadvantages of tungsten lamps, these being the high wattage involved together with the consequent heat dissipation and also the spotty effect so often produced. Cold cathode lamps in particular, have many characteristics which suit them for this purpose. In particular, there is a very large range of warm colours which may be used in many combinations to give the most suitable colour and amount of light. They may also be shaped to fit into a cornice of any length or shape, and can always be arranged to give a continuous line of even light. Perhaps the most frequently used combination is a twin line of white and gold lamps. This arrangement is available in a number of variations all of which give a pleasant mellow light which has been found entirely suitable for this type of work. The previous remarks about the use of other



Two ceiling fittings in satin silver metalwork and champagne coloured glass. The diameter of the pendant fitting is 2 ft., the other measures 20 X 30 inches.

tain types of interiors which are by no means period, but where period fittings give an interesting and a quite charming decorative effect. In such cases, it will often be found that the crystal glass chandelier provides the right touch. As before, do not forget to add the finishing touches with wall brackets and table and floor standards as appropriate. Where it is necessary to use ceiling fittings, which are more usually of the modern style, it is important to remember that there will be a greater divergence of light and shade on the ceilings and also less reflected light therefrom. Here, again, other types of fittings should be used to fill in the gaps.

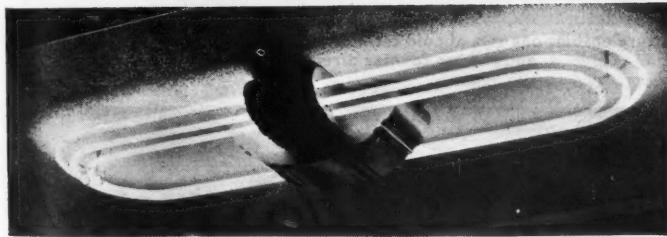
As already mentioned, indirect lighting, particularly cornice lighting, is frequently used now as the present hot and cold cathode light sources are particularly suited for this purpose. Their use obviates



small light sources to give interest are obviously equally applicable to this type of installation. Cold cathode lamps, of course, have many other uses well known to the lighting engineer, an example being the decorative unit on opposite page.

Architectural or built-in lighting is really one of the most attractive forms of lighting, and when used skilfully can be in almost any form; it might be a group of cornices arranged across the whole of a ceiling, lay-lights of any size or shape, illuminated niches or wall features, luminous pillars and door surrounds, these being only the more obvious possibilities. However, present circumstances in general do not allow of structural or new building work and therefore

The use of table standards provides small touches of interest in this indirectly lighted grill room.



A decorative cold cathode fitting with one gold and two white lamps, 6 ft. 11 ins. in length.

many of these very decorative forms of lighting must be shelved until such time as adequate provision may be made for their use in a building. It is, perhaps, worth observing that all types of built-in lighting should be considered in some detail from the architectural point of view. In other words they should be designed so that they look right and form part of the general atmosphere of the room in addition to the obvious matter of being reasonably efficient.

A further point to note in connection with various establishments is that different amounts of light are required according to the clientele and the use to which the room is put. One does not have to travel very far at home or abroad to find a number of restaurants with too much light and a number of lounges and writing rooms with far too little light. It does seem strange that this should so often be the case.

It is difficult to discuss decorative lighting

for any length of time without encountering the protagonists of tungsten or fluorescent light sources. As in so many other things, the real answer is to be found in moderation, and there are fields in which each light source is supreme. The sensible lighting engineer will endeavour to use both types of light source in a well-balanced scheme, using the appropriate light source according to its merits.

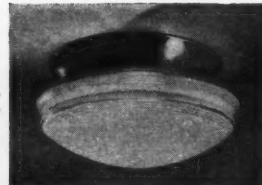
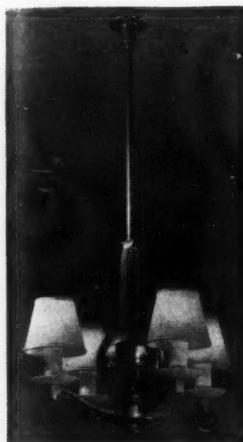
As the art and science of lighting grows more complicated it becomes increasingly bound up with the rooms as a whole, and, of course, with the decorations. This being so, it is very worth while for the lighting engineer to be in full possession of the details of the decorative scheme in the early stages of discussion. It is even a great advantage for him to consider the actual colours and textures of surfaces in relation to the lighting, even to the extent of advising the client on these matters where



**Skilful architecture enables one run of cold cathode lamps to light the room indirectly and the bar counter directly.**



**Two levels of ceiling enable the lighting engineer to provide an interesting indirect lighting scheme, relieved by wall brackets, curtain lighting and a built-in feature.**



(Above). An attractive ceiling fitting for use in a small bedroom with a low ceiling.



(Left). This small, inexpensive chandelier houses four 60-watt lamps and would look well in bedrooms.

(Above). Two of these standards on a dressing table would provide excellent mirror lighting.

necessary. It will not be out of place to mention one very important point in this connection—the matter of dark wall surfaces. Many a lighting scheme is ruined by dark walls and equally dark and depressing hangings, both of which could, with advantage, be lightened in colour.

When discussing the lighting of public rooms one is naturally led to thoughts regarding the bedrooms. Regrettably, this is the stage where financial stringency appears to set in, and no fitting is too cheap to merit consideration. To say the very least, this is a pity, as no doubt the rooms will be expensively furnished and carpeted, whereas the lighting fittings are expected to look handsome at the price of a pair of pillow-cases. For reasons which are obvious the bedroom requires just as good lighting as any other part of the hotel, and also a touch of decorative feeling about the lighting would make the bedroom of our hotel just that much superior to the one round the corner and, therefore, likely to be remembered on the next visit. Illustrations show two suggested fittings which are both simple yet elegant, and also one method of lighting the dressing-table, which is too often ignored altogether. In addition, it is as well to remember that some people like to read in bed without contorting themselves into horrible shapes, while men do like to shave at a mirror where they can see what is going on.

Before we leave the building, reference must be made to the fact that floodlighting is once more in the lighting engineer's reper-

toire, and hotels and restaurants are very suitable buildings for the exercise of this art. However, it should hardly be necessary to stress the fact that some artistry should be employed in planning the floodlighting to give a discreetly attractive effect, as opposed to a flood of light like a fair-ground, since it is, after all, first impressions that count.

### Errata

We regret that the lighting installation at Stratford Court, London, illustrated on page 166 and described briefly on page 190 of our May issue was wrongly attributed to Courtney, Pope (Electrical), Ltd. The installation of the cold cathode lighting was actually carried out by Electrolumination, Ltd., to whom we apologise for our error.

We must also apologise for an error on page 307 of the August issue in which the caption "Classroom Exhibit by the B.R.S." should have been "Classroom Exhibit by the L.S.B."

### Obituary

It is with regret that we announce the death in London on September 2 of Mr. Dean Chandler. Mr. Chandler had long been associated with gas lighting. He joined the South Metropolitan Gas Company in 1900 and was with them until 1948, when he retired, his appointment at the time being Chief Technical Officer (District). He was responsible for the design and development of the famous "Metro" domestic gas burner. Our sympathy is extended to Mrs. Chandler in her sad loss.

# The Old Cock Tavern, Fleet Street



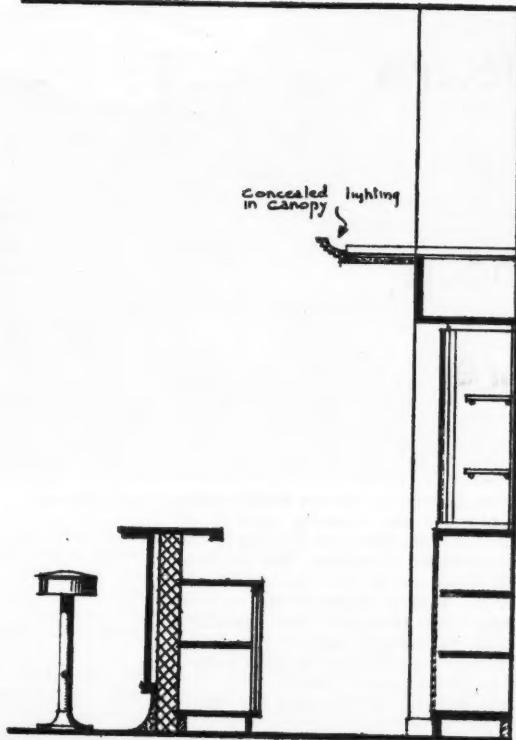
A comparatively recent addition to the Old Cock Tavern in Fleet-street is a buttery beyond the bar on the ground floor. Very little daylight penetrates into this buttery, and the artificial lighting scheme has been designed with concealed light sources to produce a reasonably even level of illumination without glare. The lighting scheme is therefore an integral part of the interior decoration.

Warm white fluorescent lamps are used for indirect lighting over the bar, the lamps being concealed in a canopy constructed for the purpose. The lamps are in reflectors fitted as near the edge of the canopy as

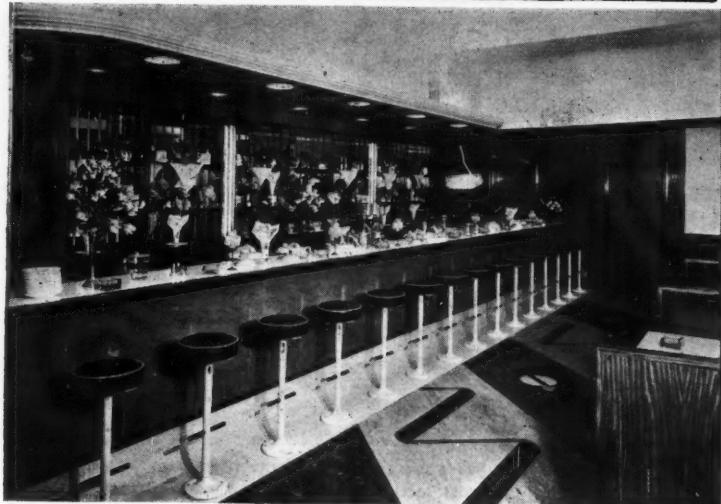
possible and running the full length of the counter. For direct light downwards on to the bar counter and service there are five "porthole" lights in the canopy, each glazed with champagne-tinted etched glass and each provided with a 150-watt tungsten lamp. On the wall opposite to the bar are two metal indirect wall bowls also containing 150-watt tungsten lamps.

The mixture of fluorescent and tungsten lighting has proved most satisfactory, and is considered to be much more pleasing aesthetically than would have been possible by the use of fluorescent lighting alone. The architect was Leonard J. Multon, of Birmingham.

(Right.) Showing plan of concealed lighting in the canopy.



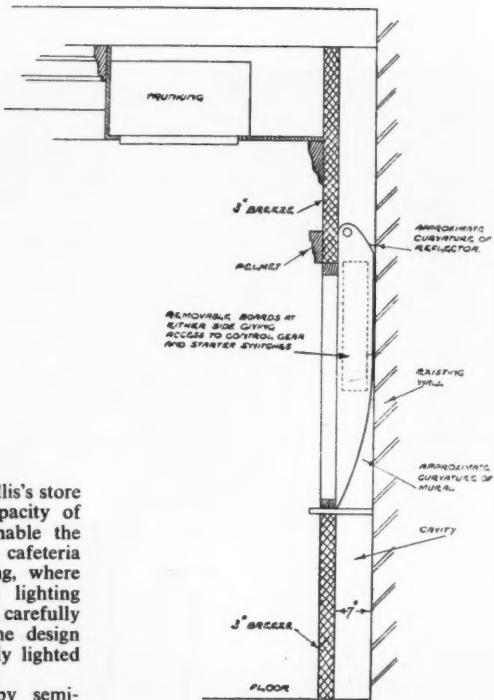
(Below.) General view of the buttery.



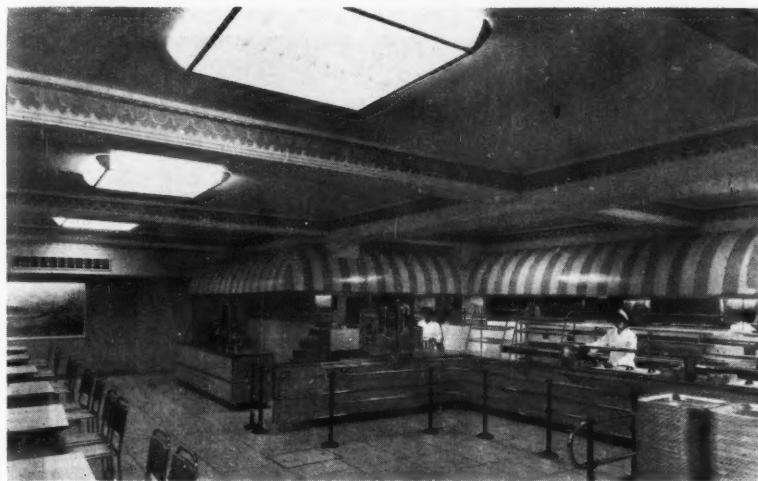
# Cafeteria in a London Store

The new cafeteria at Thomas Wallis's store in Oxford-street has a seating capacity of 300 and has been designed to enable the quickest possible self-service. The cafeteria is in the basement of the building, where there is no natural lighting; the lighting installation has therefore been carefully planned as an integral part of the design with artificial windows and skilfully lighted murals to give a sense of depth.

General lighting is provided by semi-



A general view of the restaurant showing the illuminated murals.  
(Above right.) A cross section of one of the recessed panels.



Showing the service counter.

recessed louvred ceiling fittings containing 3-ft. and 18-in. "natural" fluorescent tubes, the number of tubes depending on the position of the fitting. The louvres are anodised gold, which, it is found, gives a more cheerful appearance than either silver or pink.

Illustrated is a general view of the restaurant, including the mural panels, each of which depict a scene of London and are lighted by two 5-ft. "natural" lamps in

special reflectors. A cross-section of one of these recessed panels is also shown.

Adjacent to the cafeteria is a soda fountain with a separate service counter which has recessed fluorescent ceiling fittings for general illumination and tungsten floodlights to accentuate the counter. Tungsten floodlights are also used at the main service counter, as it is thought that this form of lighting is more acceptable to the public when selecting food.



View of the recessed lighting over the counter of the soda fountain.

# Restaurant One-O-One Glasgow



Entrance to the restaurant.

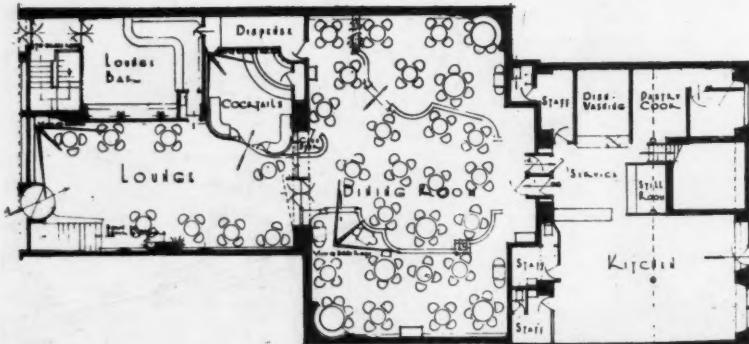
## Lounge

The lighting in this section of the building is in complete contrast to that in the restaurant itself. The fittings, designed for decorative effect, are two 12-light chandeliers constructed of wood. They are approximately 6 ft. 6 in. in diameter. The shades are designed to harmonise with the general scheme of decoration. The wall

brackets are of similar design to the main fittings.

## Restaurant

The lighting in the restaurant itself is almost entirely indirect by means of continuous lines of gold and ivory cold cathode tubing in cornices. Approximately 800 ft. of tubing is used. The ceiling layout con-



Plan of the restaurant and lounge.

sists of a centre bay with a smaller bay on each side. Each bay has a glass laylight which allows natural lighting to enter by day and at night is illuminated from above by means of tungsten fittings. The cold cathode tubes are concealed in coves facing up towards the laylights.

The undersides of the beams between the bays are relieved by the incorporation of small recessed tungsten fittings.

During planning, it was decided to house the transformers outside the restaurant in two special annexes, thus allowing the surface of the coving to remain unbroken.

The restaurant was designed by W. A. Gladstone, A.R.I.A.S., M.I.N.S.T.R.A., and the lighting equipment provided by the General Electric Co., Ltd.



(Above.) The lounge which is lighted by chandeliers and wall brackets.



(Left.) General view of the restaurant.

## Other Recent Installations

*Lighting applications in the basement restaurant of a store, a London luxury hotel and a seaside hotel.*



### Garlands Ltd., Norwich

A new restaurant has recently been opened in the basement of Garlands Ltd., Norwich. The ceiling is rather low, but the use of indirect cove lighting in the centre of the restaurant gives the effect of increased

ceiling height. The lighting of this cove is provided by eight 8 ft. 6 in. slim-line fluorescent lamps of "natural" colour. Contrast is given by the use of twenty-five 150-watt tungsten filament semi-recessed fittings around the perimeter of the restaurant, in-



(Left). The Washington Hotel, Llandudno.

(Above). Restaurant at Messrs. Garlands, Ltd.

cluding the service counter. The rose-coloured "Perspex" diffusers give a warm, cheerful atmosphere.

It has been found that the colour-rendering properties of fluorescent lamps in restaurants is most important near areas where food is displayed. In this installation the combination of fluorescent with tungsten has proved very satisfactory.

#### **May Fair Hotel, London**

Mirror lighting in the ladies' cloakroom at the May Fair Hotel is provided by means of architectural striplite lamps in trough

by six fittings, each of which consists of three 3-ft. fluorescent tubes carried vertically and three 150-watt tungsten lamps carried in a bowl below the fluorescent lamps giving indirect lighting. The bowl also houses the control gear for the fluorescent lamps. A high intensity of lighting is obtained with the fluorescent lamps, the indirect tungsten component being used to soften and improve the general appearance of the installation.

The tungsten component also has a very important bearing on colour rendering, a factor of considerable importance in the



Mirror lighting at the May Fair Hotel by architectural lamps housed in trough fittings.

fittings above the mirrors. The troughs give both upward and downward lighting and have star piercings along the front faces to give interest and "lightness" to the fittings. The visible metalwork is aluminium, anodised copper with the divisions and framing finished in satin chrome. The fittings are glazed, the base glasses being tinted a pale peach colour. These fittings provide adequate general and local lighting and their design harmonises well with the other fittings and fixtures in the hotel. The lighting fittings were designed by Messrs. Troughton and Young (Lighting), Ltd.

#### **Washington Hotel, Llandudno**

Lighting in the dining-room of the Washington Hotel, Llandudno, is provided

public rooms of hotels which are regularly used by women. The colour rendering of the light sources also has to be considered in conjunction with the furnishings and interior decorations.

The design of the fitting in this installation is of interest, being a departure from the usual elongation that is associated with fluorescent lamps. This method of mounting these lamps lends considerable scope to the imaginative designer, particularly in the use of the shorter lamps, and often enables fluorescent fittings to be used where they had previously been ruled out for aesthetic reasons. The lighting fittings were designed and manufactured by Messrs. Allom Brothers, Ltd., for the proprietors, Messrs. Ind Coope and Allsopp, Ltd.

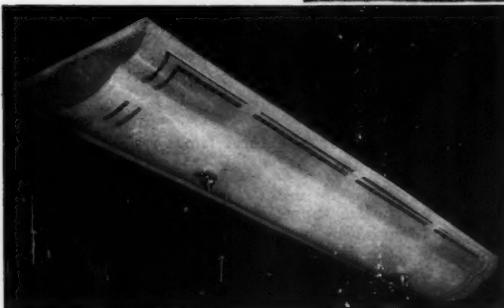
# Hotel Lighting Fittings

Several of the articles in this issue deal with lighting in hotels and restaurants. Below is shown a small selection of available fittings for use in public and private rooms.



Fluorescent fitting using two or three 5-ft. lamps. Moulded plastic diffuser is open at the top to allow illumination of the ceiling. (British Thomson Houston Co., Ltd.)

Copper anodised aluminium centre bowl with removable louvres beneath. The reflector above the bowl is stove enamelled. Designed for use with a 300-watt lamp. Suspension is anodised aluminium of a variety of colours. (Troughton and Young (Lighting) Ltd.)

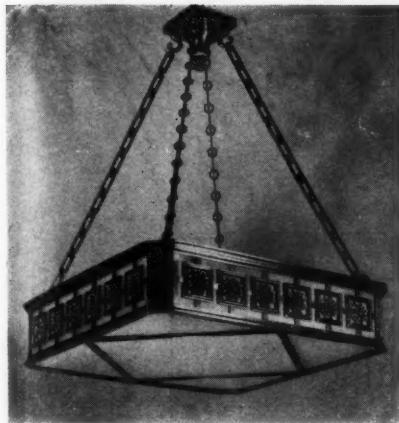


Another fluorescent fitting using two 5-ft. lamps for mounting direct on to the ceiling. (British Thomson Houston Co., Ltd.)

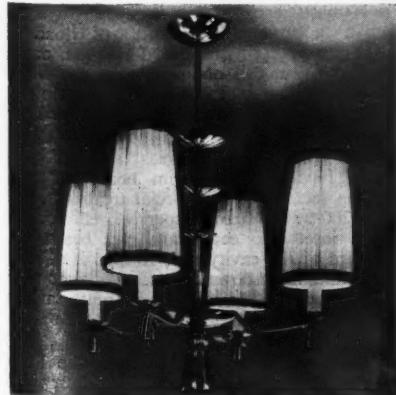
The "Steplite Halo" fitting—a glass unit consisting of a three-tier stepped bowl with a removable glass panel, mounted in a metal ring which carries a glass halo. Finished in chromium plate or natural bronze. (Holophane Ltd.)



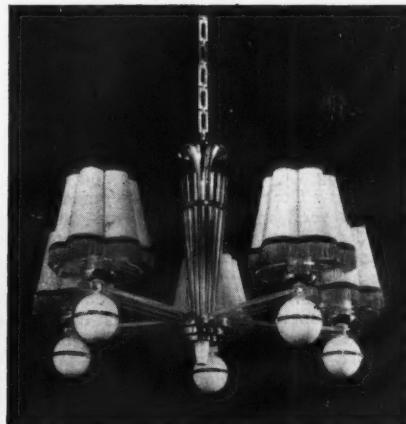
28-in. diameter "Harcourt" pendant fitting comprising extruded section band with cast ornamentation; fitted with reeded and sandblasted glass panels.  
(The Edison Swan Electric Co., Ltd.)



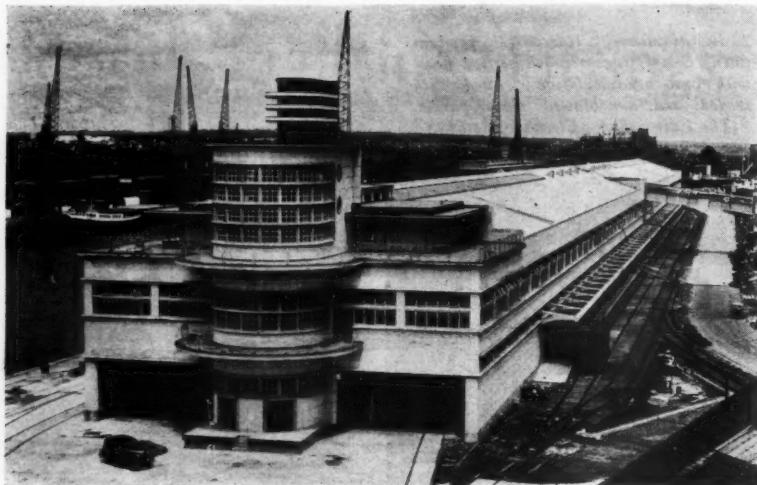
Five-light pendant consisting of brass body finished in polished copper covered with clear glass rods. Arms of channelled "Perspex." (Falk, Stadelmann Ltd.)



Special decorative fluorescent fitting using four 24-in. 40-watt "Mellow" or "Warm White" lamps. Made of cast and extruded bronze and glazed with satin etched glass panels. (Falk, Stadelmann Ltd.)



Four-light fitting specially designed for use in a suite of reception rooms used mainly for wedding receptions. The metalwork is silver-plated and lacquered. The shades are nylon with pink tinted lining. (Troughton and Young (Lighting) Ltd.)



## Ocean Terminal Southampton Docks

**The following article describes the lighting at the new Ocean Terminal recently opened at Southampton.**

Lighting a building of the size and design of the new Ocean Terminal at Southampton raised several interesting problems, and it was decided at an early date to treat the ground floor, Customs halls, and waiting halls as separate entities, giving independent consideration to each section.

Direct tungsten lighting has been used for the ground floor area, which is mainly intended for large handling and, as the maximum available mounting height is comparatively small, a spacing of approximately 20 ft. in both directions gives a symmetrical layout. An intensity of illumination of 4 lm./ft.<sup>2</sup> candles at floor level was adopted. This is obtained by using 300-watt lamps in dispersive vitreous-enamelled reflectors, to which are fitted adjustable anti-glare filament shields to obviate discomfort when looking down the length of the building.

The supply is taken from a 100-amp.

T.P. and N. section board in the ground floor switchroom by four-core P.I.L.C. cables to four distributing positions, each having three single-phase, double-pole, 8-way, 30-amp. fuseboards. The distribution points are at the north and south baggage conveyers, and the two emergency staircases and all switching, with the exception of the island rail platform, is arranged at these points.

An approximate balance of load is arranged at each fuse-board position, and a further balance is obtained when the whole installation is used by suitable phasing of the four distributing positions back of the section board.

The canopy over the east side rail platform having a maximum height of only eleven feet called for special treatment, and one 200-watt R.L.M. dispersive reflector has been inset into each cantilever beam. A closure of the cavity thus formed is effected by aluminium cover-plates, and clear-visor glasses give a finished appearance whilst reducing the collection of dirt on the reflecting surfaces.

Additional lighting to facilitate the loading of box wagons, etc., has been provided

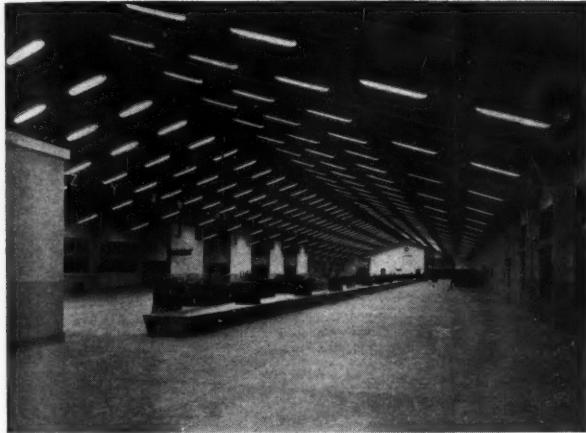
at the west side rail road by means of 300-watt angle-elliptical fittings mounted 12 ft. above floor level; 15-amp. and 5-amp. switched sockets for general use are provided at 18 positions.

The total number of main lighting points on the ground floor is approximately 400,

lamp fittings on the ground floor luggage rooms and outdoor areas were supplied by the Simplex Electric Co., Ltd.

#### First Floor Customs Halls

To preserve the contour of the roof so that the appearance of the halls retained its



The first floor Customs hall lighted by 5-ft. 80-watt fluorescent lamps.



The south end of the Customs hall on the ground floor.

with a loading of 115 kw. Besides the main lighting there are a considerable number of small lighting points in the offices, etc., and together with local heating, these bring the total loading, excluding machinery on this floor, to approximately 155 kw. The tungsten

proportions at night, standard five-foot 80-watt fluorescent tubes in vitreous-enamelled industrial reflectors manufactured by the British Thomson-Houston Co., Ltd., have been used. They are supported on special steelwork attached to the purlins, thus fol-

lowing the slope of the roof instead of the more normal horizontal suspension.

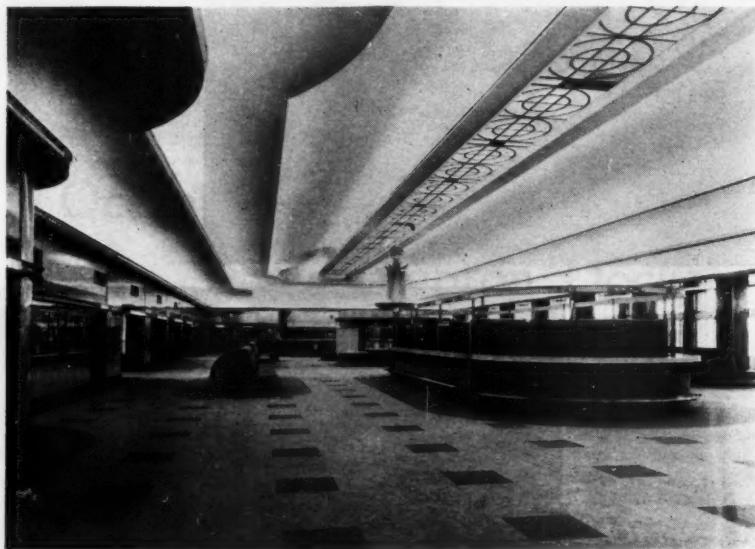
The illumination has been designed to give an intensity of 12 lm./ft.<sup>2</sup> at the Customs examination benches, falling off to 5 lm./ft.<sup>2</sup> at the walls. The fittings are spaced at 9 ft. centres transversely and 20 ft. centres longitudinally at the two transverse positions nearest each wall, and 10 ft. centres for the remaining six centre positions. In general, eight tubes are connected to one circuit controlled by a 15-amp. switch.

The supply to each hall is taken from a 60-amp. section board in the adjacent first-

#### First Floor Waiting Halls

Indirect lighting by means of high-tension cold cathode fluorescent tubes concealed in suitable cornices has been used, and consists of two lines of warm white and one line of amber tubes designed to give an illumination intensity of 7.5 lm./sq. ft. at normal working plane and to give a pleasant colour to the surroundings. Each line of tubes consists of 8 ft. 6 in. tubes overlapped at the ends to give a continuous light source.

The supply is taken from the adjacent first floor switchroom through "Castell" locked switches to fuseboards situated in the space between the suspended ceiling and the



The first-class waiting hall, showing the cornice lighting.

floor switchroom to distribution boards situated under the east wall windows in the first-class hall. At each distribution board position group power factor connection capacitors are installed together with the multi-gang switches controlling the circuits.

Auxiliary lighting is provided in each hall by means of 500-watt dispersive reflectors at 20-ft. centres in the peak of the roof. These points are switched at the entrance to the first floor on the emergency staircase.

The total number of fluorescent lamps is approximately 600, with a loading of 48 kw.

From each fuseboard the supply is taken to the step-up transformer, and from each fuseway the primaries of six transformers are fed. The transformers are situated at the ends of each line of these tubes, thus keeping the high-tension leads to a minimum length. This arrangement gives 2,000 volts across each line of three tubes, and the transformers are rated at 120 milliamps maximum for the warm white tubes and 60 milliamps maximum for the amber tubes. The total number of tubes is approximately 4,500, with a loading of 210 kw.

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# Lighting in Relation to Plant Growth

Much research has been carried out on this subject during recent years and a number of articles and papers have been published in various countries from time to time. The following article summarises the present position and will be most useful to the many people who are now interested.

Any grower of plants, whether nurseryman or research worker, who has use for artificial lighting will be dissatisfied either with the amount of light nature gives him or its quality. Or speaking from the point of view of the lighting engineer, the grower should be dissatisfied. This is no new situation for, after all, most people who use artificial lighting have the very same ideas in mind. However, in assessing the usefulness of light for plant growth, we are not so much concerned with the judgment of the human eye or a photographic emulsion but that of the plant, a very different thing.

All are very well aware that without light there is no crop, but fortunately or unfortunately as the case may be, there is more to it than churning light in at one end and getting a crop out at the other. Recently there have been a number of comprehensive reviews of this subject, some of which will probably have been seen by most readers. There is the technical report published by the Electrical Industries Research Association (<sup>1</sup>), which not only covers the field quite comprehensively but also contains an excellent set of references. More recently van der Veen has given a very readable outline of the position, in Phillips Technical Review (<sup>2</sup>). About the most useful of those with a more botanical flavour would be Shirley's review of "Light as an Ecological Factor" (<sup>2</sup>). It is concerned more particularly with field conditions. Comments

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on the means in which light controls plant growth will therefore be limited to a brief résumé. Perforce it tends to gloss over the incompleteness with which we yet understand many of the processes described.

## Energy for Growth

By far the most important and best known function of light is as a source of energy for plant growth. In this phenomenon, termed photosynthesis, energy from radiation within the approximate range 3,800—7,000 $\text{\AA}$  is absorbed by the green leaf pigment, chlorophyll, and used to energise the synthesis of  $\text{CO}_2$  and water to simple sugars. Subsequent chemical changes, not dependent on light energy, convert these sugars to starch and later cellulose and other structural products and, with the addition of nutrients absorbed from the soil, to proteins and the rest of the little understood ingredients that make up the chemistry of life.

The energy for these chemical changes, and all the work a plant carries out taking in its food and growing, is provided by the chemical breakdown of various compounds, ultimately to  $\text{CO}_2$  and water. The whole is described by the collective term respiration.

The initial photochemical reaction is controlled largely by the quantity of light available, but all subsequent steps both in synthesis and breakdown appear to act as normal chemical reactions, i.e., raising temperature by 10 deg. C. approximately doubles their rate.

From this it follows that the various situations which will be met most frequently by readers, either as lighting engineers or gardeners, can be conveniently grouped under three headings.

Firstly, there is the case where the low temperature so slows down the plant's chemical reactions that it cannot make full use of the available light. Anything grown in the open meets this situation every

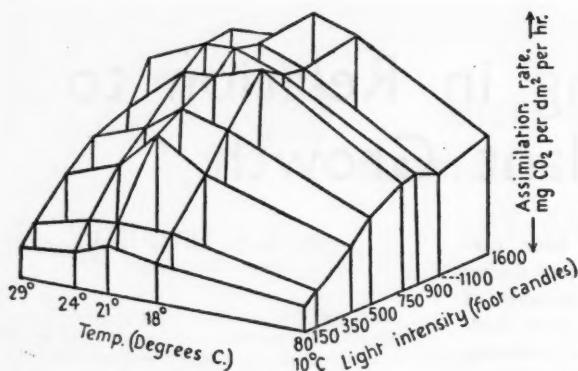


Fig. 1. Drawing of a three-dimensional model representing the interaction of light and temperature on mean net assimilation rate.

winter and spring. The answer is, of course, not a lighting problem.

Secondly, there is the case where the temperature conditions are satisfactory, but shortage of light limits growth. This is probably a regular occurrence in heated glasshouses during the winter, and remedying the situation is an inviting field for the lighting engineer.

Thirdly, under high temperature conditions the rate of loss of energy in respiration, a process controlled almost entirely by temperature, may begin to overtake the rate at which light energy can be absorbed and the overall rate of plant growth suffer accordingly. For all plants there is an optimum temperature for growth; and further, the lower the light intensity the lower is this optimum. The less the light energy available, the sooner does the rise in respiration loss come to offset the net energy gain. There is little precise data on this situation suitable for answering field queries, but many glasshouse growers are well aware of the position and allow temperatures to fall during the dullest part of the winter. From the reverse aspect any sizeable increase in light intensity provided by artificial lighting will justify maintenance of higher temperatures than those found best for natural lighting conditions. Often, of course, the extra heat from the lamp installation itself may meet the situation.

Temperature apart, the rate at which light energy is absorbed is limited at low intensities by the quantity available, but as light intensity increases the capacity of the plant becomes an increasingly important limiting factor. The law of diminishing returns is operating. At intensities of about 100 lumens per square foot energy gain is just about

balancing energy loss, the so-called compensation point. In many glasshouses light frequently drops during winter to levels not much above this, and the position is made worse by the very short period during which there is any natural light. Just above the compensation point increases of a few hundred foot candles give big increases in growth, but with continued rise the returns become increasingly small and finally cease at "saturation" level. The exact positioning of this light saturation level is still a matter for debate among botanists, and it undoubtedly varies widely from plant to plant. To give a broad generalisation, it is probably between 1,000 and 4,000 lm./ft.<sup>2</sup> for the majority of plants. Therefore, in commercial work considering the use of light to improve overall growth of specialty crops, the expected return from attempting to improve on intensities already approaching 1,000 lm./ft.<sup>2</sup> for 10-12 hours per day will be small. It is during the winter and early spring that light supplementing may give good returns. This short operating period does focus attention on the capital cost more than the running cost of any light installation.

This whole story of the close relationship between light and temperature in controlling plant growth is well illustrated by the growth of Duckweed (*Lemna minor*) in experiments carried out by Ashby and Oxley (5). They summarised their results in various three-way diagrams. We have chosen that showing net assimilation rate, e.g., the rate at which each square centimetre of leaf produces weight gain in the whole plant. There is little increase with light intensities above 750 lm./ft.<sup>2</sup> from tungsten lamps and the effect of tempera-

ture is that there is an adverse effect above 21 deg. C.

### Spectral Composition

In discussing light intensity we have been speaking in terms of lumens per square foot. Actually most botanists still use the older term foot-candles. In comparing the efficacy, however, of light sources of widely different spectral composition there is need for caution in view of the special nature of the spectral absorption curve of plant tissues. Hoover (10) has measured a plant's spectral response curve by its rate of  $\text{CO}_2$  absorption from the air. One of his response curves for a wheat plant is shown compared with that of the standard eye response in Fig. 2.

What is true for a wheat plant is true for most plants. Luminous intensity alone is not sufficient to determine the efficacy of a given radiation for stimulating plant growth. It appears that the quantity of energy in the red and blue regions of the spectrum are perhaps most important.

In the ultra-violet region radiation below 2,900 Å appears to be definitely harmful, while in the region 2,900 Å to 3,800 Å available data does not appear to indicate

any special properties for stimulating growth. As far as is known infra-red radiation has no direct benefit but too much of it may be harmful. The plants do not relish being half cooked.

### Control of Development

So far we have discussed light as an energy source, but it also plays an important role in guiding the course of development. Such things as whether or not a plant comes to flower, whether it grows long and spindly or short and sturdy are light controlled. These effects are of considerable interest not only to research workers but also to nurserymen. From the lighting engineer's point of view they have the attractive feature of being not closely dependent on the quantity of energy supplied. The number of hours of light and its spectral quality are the chief determinants.

In the "photoperiod" effect the number of hours of light during the day controls the onset of flowering. The so-called "long day" plants will only flower when there are at least 14—16 hours of light per day (radish, lettuce, potato, ryegrass, wheat); others, the "short-day" plants, are brought to bloom by a daily light period of under

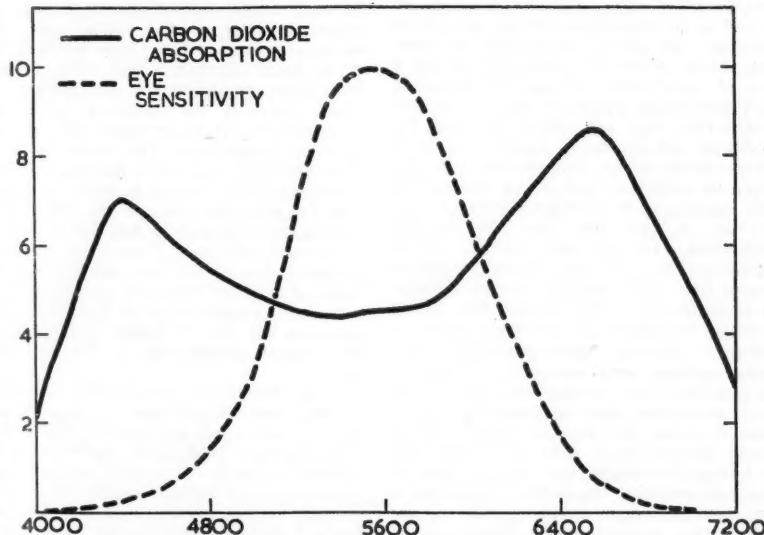


Fig. 2. Curves for eye sensitivity, and carbon dioxide absorption, i.e., rate of photosynthesis of a wheat plant, at equal spectral energy. The eye responds most to radiation between 5000 Å and 6000 Å whereas the greatest light utilisation by a green leaf occurs above and below these limits.

12 hours (French beans, chrysanthemum, cosmos, sorghum); still others, the day neutral plants, just do not care and come to flower irrespective of day length (tomato, rose varieties, carnations, and many short-lived garden weeds).

In many respects the control of flowering is the plant equivalent of the stimulating of the hen's winter laying by extra lighting, or the use of night lights to bring thoroughbred horses into season at the required time of year.

Besides flowering, the length of day affects many other development processes, including the laying down of tubers, as in the potato, the onset of winter dormancy, and stem elongation in some herbaceous plants.

Any general classification of plants such as the above grouping to "long day," "short day," and "day neutral" types always needs to be regarded with caution. The exact requirements of different varieties of the same plant may vary considerably, e.g., in Soya bean the variety Biloxi is a short-day plant and the variety Mandarin a long-day plant; the stage of development at which the light stimulus is applied is of importance; and changes in temperature may override photoperiod effects. This is by no means an end to the modifying factors in what at first sight appears a straightforward situation. These points are not raised to put a halo of complication around the botanist's work nor to talk down the very real potentialities this effect can offer nurserymen for producing out of season flowers, plants in better conditions for propagating, etc., but rather to emphasise that unless approached with caution initial disappointments may discredit a promising line of lighting application. To give one example of its application, use of photoperiod effects to control time of blossoming has been found an excellent device for meeting the market needs of the American cut-flower trade.

Before leaving photoperiodism two further points merit comment. Firstly it has recently been shown that for "long day" plants the onset of flowering can be induced either by keeping lamps on to extend the period of light or equally well by letting the plants grow in short natural day, and switching the lights on for only a few minutes exactly in the middle of the night. One worker reports 40-foot candle minutes of light sufficient for this method, about a tenth the quantity of light required with conventional procedure (9).

Secondly, any visible light will not serve equally well to induce the reaction. There

is a zone of maximum effectiveness in the red, between 6000 Å and 6600 Å a rapid falling off below that, and a very minor subsidiary peak about 4500 Å (9).

Intensities required are low. For the conventional procedure of leaving lights on for several hours to extend natural day length as little as 0.5 lm./ft.<sup>2</sup> has been effective in some cases. 15-20 lm./ft.<sup>2</sup> is considered ample for general use, and 40-50 lm./ft.<sup>2</sup> the outside limit.

To briefly consider another type of light control. The spectral quality influences the general form of a plant's growth. A number of workers have found that red light gives tall, spindly plants and blue light short sturdy ones, but generally with much less total growth. Photographs by van der Veen and Withrow (1), (11), illustrate the point. American workers found that neither light alone gave as much growth as a combination of both (2).

#### Lighting Applications

From this very brief resumé of the relationship between light and growth a number of possible uses for supplementary lighting by nurserymen and specialty vegetable growers will come to mind. It can be used to get out of season flowers and fruits, to improve the winter and early spring growth of mature plants and seedlings, or to break dormancy and bring material into better condition for propagation. A close study of the situation would undoubtedly reveal many other uses to meet specialised problems. The writer is not in close personal touch with this aspect of the problem in England and is unable to suggest how far these are commercial potentialities waiting to be tapped or how far it tends to be wishful thinking. That is an extremely practical issue calling not only for a knowledge of lamp performance and cost, and of the special requirements of individual plant varieties, but also of market conditions and the general organisation of the individual nurseries.

There has been considerable discussion on what are the best types of lamps to use, and the writer has no wish to add to that. A recent paper by Withrow and Withrow (11) summarises the previous work and gives very interesting experimental results from comparisons between 400-watt mercury vapour lamps, standard fluorescent tubes, and tungsten filament lamps. Remembering fully that an ounce of practice is worth a pound of theorising, he will risk commenting on one or two implications of the situation. With lumen efficiency being no real measure

of a lamp's usefulness for plant growth, and the probable use of equipment for only a short period each year calling for low capital cost, any tendency to regard "daylight" or similar type fluorescent lamps as an all-purpose answer requires caution.

For photoperiod effects tungsten filament lamps have been found quite satisfactory, and in combination with the new blue fluorescent tubes may even be an economical source of light energy for improving general growth. This is a definite speculation for the high proportion of infra-red from tungsten lamps limits the intensities which can be used without ill effects. Where much of the light comes from unscreened tungsten lamps the resultant tall and spindly growth would often be unsatisfactory for nurserymen, etc. It has been shown that tungsten lamps will raise the temperature of the plant leaf up to 15 deg. F. (11) above the surrounding air temperatures. Growth at high temperatures under low light is normally spindly, and much of this adverse effect from tungsten lamps may possibly be overcome by a deliberate lowering of the glasshouse temperatures, so that the actual plant itself is at more normal temperatures.

For the higher light levels for direct growth promotion, fluorescent tubes have been used successfully over small areas, but over large areas the cost of the large number of tubes and control gear may become prohibitive. Where a grower can make good use of an increase in light intensity of some hundreds of lumen per square foot over an area of several hundred square feet the newly developed Xenon arc does suggest interesting possibilities. The extremely high luminous flux from a single lamp, a hundred thousand lumens and upwards, implies convenience of installation in existing glasshouses. Its light approximates sunlight quality in its own right with a rather higher emphasis on the red end. A combination which does suggest plants would enjoy these conditions and respond accordingly.

#### **Lighting as an Aid to Botanical Investigation**

Turning now to the use of lighting in botanical research, the field of work with which the writer is now particularly concerned, we find that there has been long continued trial and use of lighting for almost all the purposes outlined. With the new light sources offering considerably greater scope, it is a field of work which may well expand considerably in the near future.

The use of lamps to extend the length of

"day" has become such standard practice as to merit little further comment. Both standard fluorescent tubes and tungsten filament lamps have been used with complete success.

One of the best recent examples of the use of artificial lighting to make up for the shortage of winter daylight is the work of A. J. Low, at the I.C.I. research station at Jeallots Hill. He was using oats, rye grass, and clovers grown in pots to test the efficiency of various types of phosphatic fertiliser. But even though his glasshouse was heated growth was so slow there was little point in trying to continue the work during winter and early spring. By mounting 45 5-ft. 80-watt fluorescent tubes at 6-in. centres 2 ft. above the plants, and running them from 4 a.m. to 10 a.m. and 2 p.m. to 8 p.m. to supplement and extend natural daylight, he was able to get growth comparable with that for midsummer, and thus continue his experimental work all the year round. (6) "Daylight" tubes were found best for growth of these plants.

The phase of work which does offer the investigator exciting possibilities is the use of lamps to completely replace natural light. This is generally done in combination with control of temperatures and, possibly, humidity, i.e., there is an attempt to set up in the laboratory a facsimile of outside weather conditions. It generally involves building rather more complex apparatus than plant experimenters usually work with, and people often ask why go to all this trouble when plants already seem to be able to grow pretty well in the field. How would a lighting engineer feel if asked to carry out design and development studies on a light source in a set-up where he knows there are not only large and uncontrollable fluctuations in supply voltage but also equally large and unconnected variations in the circuit resistance. If we now substitute for voltage and resistance, light intensity and temperature, it gives a picture of the conditions plant experimenters have normally to face. They have, of course, developed techniques to meet this situation. With these it has been possible to gain a comprehensive outline of how a plant operates but the fundamental difficulties remain, and in particular have made it difficult to put the plant physiologist's ideas into the precise quantitative form of most use where the knowledge is required for assisting field problems.

The widest use of controlled environment techniques will be for fundamental studies of plant growth, a field of work sufficient

to keep many men busy for a long time. Rather apposite for present conditions is the study of the growth efficiency of field crops. In terms of light energy converted to plant energy most crops are less than one per cent. efficient. It is known that some, such as sugar cane and maize, have achieved efficiencies well above this. Levels of over 4 per cent. have been recorded. With the world population at present increasing much faster than foreseeable gains in food production, any prospect of even a  $\frac{1}{4}$  per cent. increase in efficiency offers breath-taking possibilities. This is a problem that bristles with practical difficulties, but if we can get an understanding of just how that efficiency is determined, many of these difficulties might look far less formidable.

That is taking a long-range view, but there is no shortage of immediate practical problems where the method offers prospect of speedily giving the answers. An example with which the writer has had close personal contact will be described. Throughout most of New Zealand the sheep and cows are fed all the year round on grass alone. Every ten years or so there occurs a peculiar combination of autumn weather conditions which, in the space of a few days, renders the grass absolutely toxic to stock. There is severe liver damage, and any exposed skin becomes light-sensitive, breaking to a mass of running sores. In severe outbreaks tens of thousands of animals have died or had to be hurriedly sent to the killing works, and many more have been permanently debilitated by their injuries. So far there is no known cure. The only method of prevention is to prevent stock from eating the toxic grass. A matter of some difficulty when all fields are covered in grass. Attempts to study this condition, known as "facial eczema," have so far met only limited success, for in between major outbreaks it has been almost impossible to get grass which is toxic. The weather just won't play ball. For this use alone workers in New Zealand have a very keen interest in being able to produce suitable "weather conditions" artificially.

Well, you say, there has been a good case made out for these artificial environment studies, but why has there not been more action? The answer is quite simple. In the past suitable light sources have not been available. It is only now that we are coming within sight of achieving that very essential prerequisite.

During the past 25 years many designs have been tried out. There is little point in attempting to describe them all, though

for any reader who may become concerned with this field of work a study of the various types of equipment built will provide many ideas of present usefulness (7, 12, 13, 14, 15, 16, 17, 18). Comment will be limited to a few outstanding examples which do illustrate design trends.

The first full-scale attack on the problem was made at the Boyce Thompson Institute, U.S.A., in the middle 1920's. They constructed elaborate rooms with air-conditioning and control of the  $\text{CO}_2$  content of the air. In some units lighting was from a battery of  $25 \times 1,000$  or 1,500-watt incandescent lamps shining through a water screen to reduce the infra-red load. In others they tried incandescent, sodium vapour, mercury vapour and neon lamps alone and in combination. Nothing appears to have provided a satisfactory substitute for good daylight, and in many cases there was severe plant damage. The gain from this work was not so much in fundamental knowledge of plant growth as in "know how" of the effects of various lamps. It has been summarised by Crocker, the Director of the Institute, in his recent book (4).

From the botanical point of view the first results of real value were those produced by Ashby and associates in the early 1930's (5). Their light came from tungsten filament lamps, each suspended in an individual water-jacket. By an ingenious arrangement of light partitions and by using two separate water tanks they could work with eight-light intensities and two temperature levels simultaneously. The plant used was Duckweed (*Lemna minor*), commonly seen as a green scum floating on the surface of ponds. For this pioneer work the plant's very lowliness was a considerable advantage. The simple form, a series of semi-circular fronds made changes easy to observe, and its growth floating on a water surface simplified temperature control. A water mass is easier to hold at constant temperature than is circulating air. There has since been little to equal their classical study of the interrelationships of temperature and light intensity with growth. Fig. 1 is an example of the results they obtained.

With the advent of fluorescent lighting it was thought at first that the answer to the difficulties had appeared. They were high-efficiency lamps, giving light very similar to daylight and virtually free of the bugbear of high infra-red load. However, original hopes have sobered down a little. Plants show little interest in direct lumen efficiency, and the low-source brightness makes it impossible to obtain intensities in

any way comparable with summer or even spring daylight. No matter how the tubes are arranged, many plants will still be asking for more light. It is possible to get up to 2,000 lm./ft.<sup>2</sup> by placing the plants a few inches from a close-set battery of

pleted "Phytotron," built for F. W. Went, at the California Institute of Technology (19). It succeeds a temperature-controlled, and partly artificially lighted, greenhouse in which he carried out valuable work on tomato plants. It is indeed spectacular in

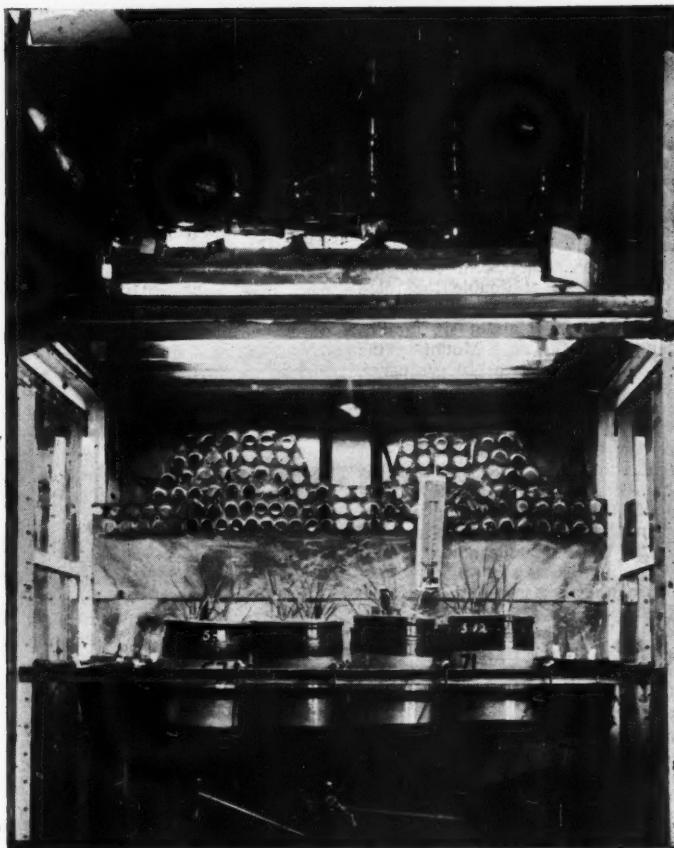


Fig. 3. Growth chamber in use at Manchester University seen with the access panel removed. There are alternate rows of fluorescent tubes and 150 watt reflector spot-lamps. For temperature control the circulating air is drawn past the grill at the back and blown down over a thermostatically controlled plate cooler.

tubes, not a very convenient arrangement, and many workers have settled for 500 lumens per square foot.

A considerable number of growth cabinets using this lighting have been constructed in U.S.A. Best known is the recently com-

plete, conception, and probably in realisation. A few particulars may be of interest. The building is 80 x 125 ft. with ground floor and basement. It contains:—

1. Six air-conditioned greenhouses, using natural light. Temperatures can be

controlled during the day over the range 58-90 deg. F. and at night from 50-68 deg. F. and relative humidity held anywhere between 15 per cent. and 90 per cent.

2. Thirteen rooms artificially lit with temperature control from 35-90 deg. F. and relative humidity from 15 per cent. to 90 per cent.
3. Eleven dark rooms with the same temperature and humidity range as above.
4. Ten miscellaneous air-conditioned rooms, including ones for wind-tunnel work, radio-active tracer work, and the production of artificial rain or fog.

Everything going in is sterilised. This includes not only the air, soil and plants but also the workers, their clothing and cigarettes.

For the artificially lit rooms 8 ft. "slim-line" 4,500 deg. K. fluorescent tubes are used. These are run at double the rated wattage by connecting two chokes to the one tube. Their life is about six months at eight hours per day. Mounting the tubes on 2-ft. wide panels at 10 per panel, and using 4 x 60-watt tungsten lamps for every nine tubes to balance the red end of the spectrum, he reports 2,000 lm./ft.<sup>2</sup> at 4 in. from the tubes and 1,500 lm./ft.<sup>2</sup> at plant height about 24 in. away. Once its teething troubles are over, and even the cost expenditure of \$407,000 does not guarantee an absence of those, we can expect a steady flow of outstanding results, for a group of first-class workers and a most comprehensive research tool have been brought together.

But, as will have been noted, light intensity is still not as great as could be wished for.

Parker and Borthwick working at the United States Department of Agriculture's station at Beltsville have sought to overcome the intensity problem by using a carbon arc source. With sunlight carbons carrying a 75-amp. current and a reflector to throw a band of uniform light around the source, they obtain 2,000 lm./ft.<sup>2</sup> at one metre. Glass is placed around the arc to cut out the short ultra-violet. Despite the intensity, growth was not satisfactory and it was found that by adding 8 x 200-watt tungsten lamps plants showed a very considerable improvement in vigour and robustness. This layout has been operating in controlled temperature rooms for some years now and has given growth as good as that in greenhouses during the spring and summer.

Finally, there is the equipment which has

recently been brought into operation at the Botany Department of Manchester University. It is intended to use it later for pasture research work in New Zealand. Accordingly, the emphasis was on light intensity and design simplicity. The extreme helpfulness of a great number of people both within and outside the university enabled us to erect a unit which has given promising performance.

For lighting a combination of 150-watt internally silvered reflector spot lamps and blue fluorescent tubes has been used to give an integrated lighting equivalent to daylight at over 2,000 lm./ft.<sup>2</sup> at 18 ins. from the lamps. Compared with daylight, this combination is rather deficient in green but strong in blue and red. Disposal of the infra-red and general heat load has been achieved by mounting the lamps outside the controlled temperature cabinet, placing a piece of O.N.20 heat-absorbing glass under each tungsten lamp and blowing 300 c.f.m. of air through the lamp loft. Even with over 2 kw. of lamp power it has been necessary to switch on a heater to hold a temperature of 70 deg. F. inside the cabinet.

For controlling the infra-red, heat-absorbing glass is more expensive than a running-water screen, but it has proved most convenient to handle and certainly eliminates the worry of leaks and clouding of the glass.

The wattage of the internally silvered spotlamps is not very high, as tungsten lamps go, but there is a minimum of wasted flux and the beam can be easily passed through a piece of O.N. 20 glass and then directed as needed to even out the light distribution.

The equipment has now been in use for five months and the growth of the ryegrass plants has appeared quite satisfactory.

It was earlier mentioned that saturation level for many plants is above 2,000 lm./ft.<sup>2</sup>. Ryegrass appears to be one of these, and attention is being given to the possibility of obtaining even higher light intensities, for until saturation level is reached it cannot be said that we have a research tool which will meet all demands from both fundamental and applied work. At the same time spectral quality must be maintained. Further gains can be obtained from the rearrangement of lamps to fit more in the same space, by using more powerful tungsten and fluorescent lamps, or from a combination of both. Such methods could probably raise intensity as high as will be needed at present.

Should even higher levels be required the

possibilities of the Xenon arc immediately come to mind. Its apparently excellent spectral composition for plant growth has already been mentioned. Directing a focused beam from one of those lamps into a growth cabinet should provide enough light to equal any intensity the sun offers and certainly to equal even the wildest imaginings of research botanists.

#### References

- (1) "Influence of Light on Plants," van der Veen, Philips Technical Review, Vol. 11, p. 43, 1949.
- (2) "Light as an Ecological Factor," Shirley, H. L., Botanical Review, Vol. 11, p. 497, 1945.
- (3) "Artificial Illumination in Horticulture," Brandon, D., Technical Report of British Electrical and Allied Industries Research Association.
- (4) "Growth of Plants—20 Years Research at Boyce Thompson Institute," Crocker, W., Reinhold, 1948.
- (5) "Interaction of Factors in the Growth of Lemma," Ashby, E. and Oxley, T. A., Annals of Botany, Vol. 49, p. 309, 1935.
- (6) "Fluorescent Lighting for Pot Culture," Low, A. J., Journal of Ministry of Agriculture and Fisheries, Vol. 55, p. 210, 1948.
- (7) "Modified Circuit for Slimline Fluorescent Lamps for Plant Growth Chambers," Parker, M. W., and Borthwick, H. A., Plant Physiology, Vol. 25, p. 86, 1950.

#### Personal

The British Thomson-Houston Company, Ltd., announce two important appointments in their lamp and lighting sales organisation.

Mr. W. C. HUSTON has been appointed Marketing Manager, Lamp and Lighting Sales. He joined the commercial side of the Mazda Lamp Department in 1931 and later became personal assistant to the director of Lamp Sales. In 1940 Mr. Huston was made manager of the BTH Lighting Department, his appointment coinciding with large-scale development of fluorescent lighting, particularly in wartime factories. Under his management the department has expanded very considerably and now embraces almost every field of lighting. In his new position he will be largely responsible for the planning and co-ordination of marketing policy for Mazda Lamp and Lighting Sales.

Mr. C. W. M. PHILLIPS, A.M.I.E.E., F.I.E.S., has been appointed manager, Lighting Department. Mr. Phillips joined the BTH company in 1927, and after completing his engineering apprenticeship was for a time on turbine test work. In January, 1934, he joined the Lamp Department, Crown House, London, his work being particularly concerned with early stages of the development of street lighting with mercury vapour lamps. During the war he worked on the develop-

(8) "Growth and Composition of Biloxi Soya-bean in Controlled Environment With Radiation From Different Carbon Arc Sources," Parker, M. W., and Borthwick, H. A., Plant Physiology, Vol. 24, p. 345, 1949.

(9) "Action Spectrum for Photoperiodic Control of Flower Initiation," Borthwick, H. A., Hendricks, S. B., and Parker, M. W., Botanical Gazette, Vol. 110, p. 103, 1948.

(10) "CO<sub>2</sub> Assimilation and Wavelength," Hoover, W. H., Smithsonian Miscellaneous Collection, Vol. 95, No. 21, 1937.

(11) "Plant Growth With Artificial Sources of Radiant Energy," Withrow, A. P., and Withrow R. B., Plant Physiology, Vol. 22, p. 494, 1947.

#### CONTROLLED ENVIRONMENT CHAMBERS

- (12) Hamner, K. C., Botanical Gazette, Vol. 105, p. 437, 1944.
- (13) Hartman, H. T., and MacKinnon, L. R., Proceedings of American Society for Horticultural Science, Vol. 42, p. 475, 1943.
- (14) Davis, A. R., and Hoagland, D. R., Plant Physiology, Vol. 3, p. 277, 1928.
- (15) Kramer, P. J., and Decker, J. P., Plant Physiology, Vol. 19, p. 350, 1944.
- (16) Parker, M. W., Soil Science, Vol. 62, p. 109, 1944.
- (17) Childers, N. F., and Brody, H. W., Proceedings of American Society for Horticultural Science, Vol. 37, p. 384, 1939.
- (18) Stoughton, R. H., Annals of Applied Biology, Vol. 17, p. 90, 1930.

ment of fluorescent lighting for factories and was appointed assistant manager of the BTH Lighting Department in 1946.

Mr. Phillips has taken an active part in the Illuminating Engineering Society and was on the committee which arranged the I.E.S. Conventions of 1948 and 1950. He was chairman of the technical committee of E.D.L.A.C. until January of this year.

Mr. J. SMITH, until recently manager of the Newcastle branch of The Sun Electrical Co., Ltd., has been appointed manager of the company's Leeds branch.

Recent appointments by Ekco-Ensign Electric Ltd., include the following area representatives: MR. S. BRAITHWAITE to South-Western Lancashire; MR. A. E. DAINTY to the North-Western Sector of Birmingham; MR. F. S. LILL for the County of Lincolnshire; and MR. C. R. LOCK for parts of Hampshire, Dorset and South Wiltshire.

Mr. W. ROBINSON has joined the technical staff of the British Electrical Development Association as their lighting specialist. He joined the staff of the E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, London, in 1937, as lighting engineer, and at the time of joining E.D.A.'s staff he held the position of chief engineer. At E.D.A. Mr. Robinson will deal with all matters concerning domestic and public lighting.

# Lighting a Private Branch Telephone Exchange

Faced for long periods with a maze of signal lamps, switches, etc., all making a confusing pattern against a polished background the seeing task of a switchboard operator is not an easy one. The lighting problem is also difficult. This article describes one method of switchboard lighting.

## Introduction

In a private branch telephone exchange the operators have an exacting and arduous task. The work involves seeing, hearing, speaking and touching. At busy times calls are often made at a rate of 250 an hour, while at the peak period calls are often handled at the rate of seven per minute for 15 minutes or more. The rate at which calls are made varies throughout the day, but the work demands the operator's continuous concentration throughout the entire period of duty. The exacting nature of the task and its strain upon nervous energy has resulted in the introduction of work and rest periods throughout the day, and any contribution which can be made towards providing an easier and more comfortable atmosphere in a telephone exchange will directly help the task.

Considerable help can be given by suitable lighting and room decoration. In the past this has rarely been done very well, illumination levels have often been low and the quality of the lighting poor. To light a private branch exchange effectively, however, involves a number of technical problems which are not easily overcome.

## The Problem

A private branch exchange often consists of a group of switchboards for the internal telephone system of the organisation, and another group of switchboards for connection to the G.P.O. telephone system, the

By H. E. BELLCHAMBERS,

A.M.I.E.E.\*

number of boards in use depending upon the size of the organisation. Generally these boards are placed along three walls of a room or in a semi-circle, with one or two supervisors' desks suitably placed to enable the supervisor to see all that is going on in the room. Fig. 1 shows an example of such an arrangement.

The switchboards are usually similar to those shown in Fig. 1 and consist essentially of a horizontal surface 27 in. x 16 in. and a vertical surface 27 in. x 24 in. On the vertical surface, which is known as the multiple board, and covering roughly the upper half of this surface, are numbered sockets in groups of 100. The group numbers are black on a white background, and the socket numbers white on black, and only the bright metal edge of the socket distinguishes it from its immediate background. Below this is another group of sockets, each with a small signal lamp beneath it. These are also numbered in black on small white backgrounds. The whole of this board is framed, except for the lower edge, with highly polished woodwork. This vertical surface normally fills the field of view of the operator; the upper part presents a whole mass of small, closely-spaced areas of black and white, and the lower part, with its slightly larger black and white areas, produces a checker-board effect. For ease of seeing, the vertical surface should be evenly illuminated to a level which enables the small numbers to be read quickly and should be free from reflected glare.

The horizontal surface of the switchboard consists of a group of jacks in pairs connected by flexible cords, a group of signal lamps and a group of switches, all of which are attached to a red fibre board forming the switchboard base. The signal lamps, like

\* British Thomson-Houston Co., Ltd.

those on the vertical board, are sunk below the switchboard face, and are covered by a small opal hemisphere which is designed to be of low brightness and visible from all angles of view. These opal covers have a disadvantage in that they reflect back a large part of the room lighting falling upon them and are therefore relatively bright even before the signal lamps are switched on behind them. Consequently the illumination on the board must be kept to a comparatively low level in order to make the signal visible. The level of illumination on the horizontal surface must, however, be sufficient to enable the operator to record on slips of paper details of time, duration, and the number of some of the calls, and on occasion to read from charts in small print at the side of the board.

It will be appreciated that the operator's visual task when using the kind of switchboard described is a complex one, and a complete analysis of all the physiological and psychological factors involved would require a very detailed and extensive investigation. A more practical approach would be to re-design the switchboard, using, for example, colour instead of brightness contrasts to distinguish between

one part and another, the use of matt surfaces instead of polished surfaces, etc., and so by these means make the visual task, and at the same time the lighting problem, easier. This re-designing of switchboards incorporating such improvements is being done, but meanwhile existing switchboards and exchanges need better lighting. The problem has been to provide improved lighting for existing switchboards, making the visual task as easy as the present switchboard design permits.

The switchboard lighting problem, then, is to illuminate both the horizontal and vertical surfaces of the switchboard evenly without masking the signal lamps; it must be done in a way that avoids both direct and reflected glare. In addition to the switchboard lighting the general room illumination must be even, avoiding large brightness contrasts and glare. The provision of an even general illumination throughout the room does not present any special difficulties, and in the past this has generally been done by using tungsten filament lamps, in diffusing bowls or, more recently, by using fluorescent lamps in fittings which direct most of their light upwards. To provide additional lighting



Fig. 1. Example of a P.B. Exchange switchboard layout.

for the switchboard it has been the practice to fit local lighting using filament lamps to the top of the switchboard, and it is here that difficulties begin to arise. The switchboard surround is generally highly polished woodwork, and it is not easy to devise a fitting for local lighting which avoids reflected glare caused by images of the source in the polished surfaces, nor can the lamp be shielded easily from the operator's view. These local lighting fittings must not project more than a few inches from the face of the switchboard, otherwise operators are liable to

fluorescent lamp fitting is attached to the top of the switchboard; this serves to illuminate the switchboard itself and at the same time provides the general illumination of the room. Fig. 2 shows diagrammatically a section through the fitting and indicates the general arrangement. It will be seen that this consists of a white diffuse reflecting surface used as a secondary source and illuminated by means of a 1½-in. diameter fluorescent lamp, so placed that no direct light can fall upon the switchboard surfaces. A system of louvres placed below the diffuse reflector is

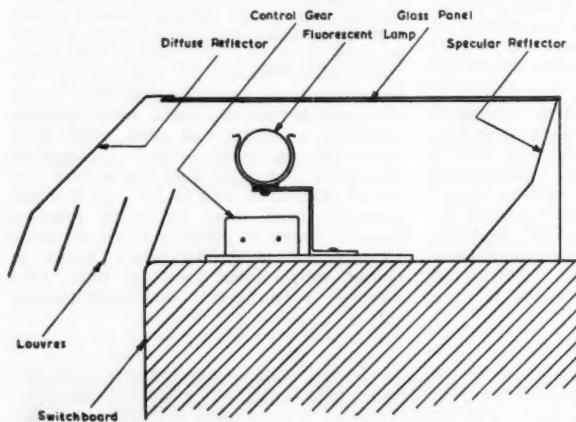


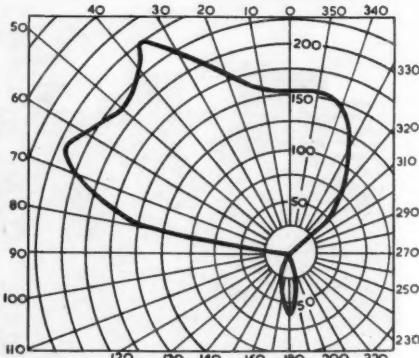
Fig. 2. General arrangement of the switchboard fitting.

Fig. 3. (Below) Polar curve of candle-power distribution from fitting.

knock their heads when rising from their seats. It has been fairly common practice simply to provide an even, general illumination of four to five lumens per sq. ft. and to leave the problem of switchboard lighting unsolved, or, alternatively, to subject the operators to glaring conditions. A general lighting scheme alone is most unsatisfactory, because however good the scheme may be, due to the size and shape of the switchboard, shadows of the operators are bound to be cast across the working surfaces.

#### Lighting of an Exchange

From the above it follows that the lighting scheme must be a well co-ordinated general and local lighting system. In an unusual approach to the problem a method which might perhaps be termed favourably directed indirect lighting has been used, providing a level of illumination on the horizontal surface of the switchboard of from 10 to 15 lumens per sq. ft. and a general level throughout the room of 10 lumens per sq. ft. A specially designed



arranged to direct light upon the horizontal and vertical surfaces so that an even illumination is provided over these surfaces, and it is directed on to the vertical surface at such angles that polished portions of the surface cannot cause reflected glare.

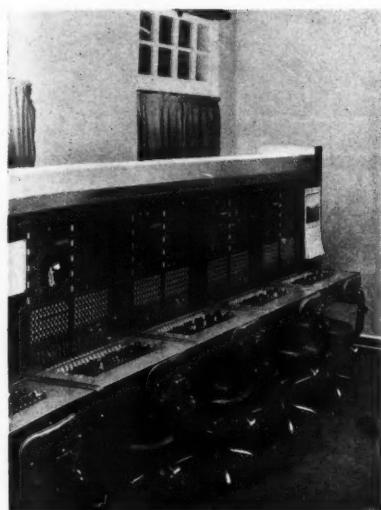


Fig. 4. A group of switchboards equipped with the new lighting fitting.

The louvres also prevent a direct view of the source by the operator. Another reflector behind the lamp directs light towards the ceiling and upper walls, thus providing the general room illumination. The lamp is arranged so that its horizontal distance from the diffuse reflector can be varied. This enables the brightness of the diffuse reflector, and hence the level of illumination on the switchboard, to be adjusted to the desired level without changing its distribution. Control gear for the lamp is housed inside the fitting and the top of the fitting is closed by a glass panel to keep out dust. Each switchboard has a 24-volt 6-watt tungsten filament lamp

attached at each end above the louvres for emergency lighting.

A polar curve of candlepower distribution from the fitting is shown in Fig. 3. The up/down light output ratio is 90/10. (It should be noted that the size of these areas bounded by the respective upward and downward light curves are no direct indication of the quantity of light falling upon the areas illuminated.) The downward light illuminates areas very near to the source, while the upward light illuminates much greater areas at relatively large distances.

In those cases where the signal lamp covers are not easily visible because of the amount of light reflected from their surface, they can be replaced with a cover

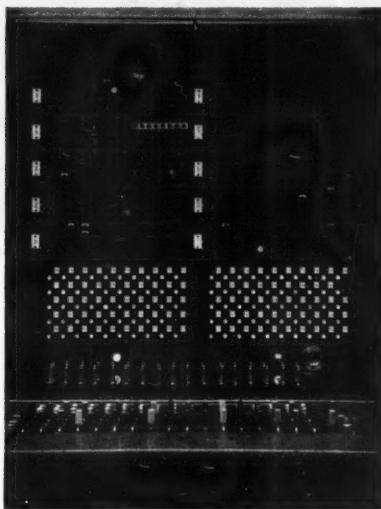


Fig. 5. A close-up of the switchboard as seen by the operator.

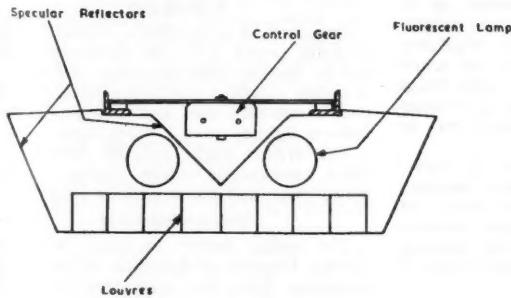


Fig. 6. (Left) Supervisor's desk fitting.



Fig. 7. Daylight appearance of the exchange.

using a translucent diffusing material which is able to transmit the light from the signal lamp in an efficient manner, but which has a poor reflecting characteristic. The covers are set at such an angle that they are visible over a wide range of angles, and the change in brightness produced when the signal lamps are switched on is much less affected by the general illumination on the board.

The photograph Fig. 4 shows a group of switchboards in an exchange which has been equipped with this form of lighting, and it will be seen that the boards are well lighted, there are no large brightness contrasts either on the switchboard or in the room. The ratio of the average brightness of the switchboard to the brightness of the general surround is 20 : 1, the actual brightness of the wall on the right being six footlamberts. Fig. 5 shows a close-up of the switchboard as it is seen by an operator.

Louvred fittings are used over the Supervisor's desk, and these have been designed to concentrate light to a level of 20 lumens/sq. ft. on to the desk without interfering with the switchboard lighting. The optical arrangement of these fittings is shown in Fig. 6.

In this exchange the colour and reflectivity

of the walls were chosen to give the desired brightness distribution and to provide a restful atmosphere in both natural and artificial lighting conditions. The walls are painted in a matt finish, using Munsell colour 5.0 G.Y. 6/6, and the ceiling is Munsell colour 7.5 Y.R. 8/2. To improve the general arrangement of the room and to reduce glare from the windows during daytime, the switchboards were rearranged in two long rows with their backs to the windows. This arrangement is shown in the photograph Fig. 7, which shows the appearance of the exchange in daylight.

#### Conclusion

This method of solving a difficult lighting problem shows how the fluorescent lamp can be used to perform a dual purpose. It provides carefully controlled local lighting over a restricted area, and also gives general indirect lighting over a much larger area.

The system might well be extended to other applications where similar requirements exist, and prove equally successful.

#### Acknowledgment

The author wishes to thank Mr. L. J. Davies, Director of Research of the B.T.-H. Company, Ltd., for permission to publish this paper.

# Calculation of Light Flux and Illumination from Extended Sources

By T. S. P. TUCK, M.Sc.

The student who sits the examinations in Illuminating Engineering of the City and Guilds Institute is assumed to have had a mathematical training up to the standard of a University Intermediate Degree Course. This involves a knowledge of elementary calculus, and this is taken for granted in most textbooks on Illuminating Engineering. By it, expressions are derived for the total flux emitted from extended sources, and also for the illumination at specified points. The student, therefore, who lacks this mathematical equipment has to accept the results, and to memorise them, a task which is not easy when the methods of obtaining them are not understood.

Many important formulae, nevertheless, can be derived very simply by methods which do not involve the use of the calculus. Students are familiar with the application of the Rousseau diagram for calculating total flux from symmetrical sources. The proof of this method is readily acceptable by students once they have been shown the relationship between the surface area of a sphere (or a zone of a sphere) and that of the circumscribing cylinder, and this is given in books on solid geometry without direct recourse to the calculus. With this as a starting point, the total flux emitted from a perfectly diffusing plane surface can be calculated, and this result used for tubular, plane and spherical sources which are assumed to be perfectly diffusing. The purpose of this note is to show how many well-known formulae can be derived in an elementary manner.

### Total flux emitted by a plane perfect diffuser

Let O be the plane perfectly diffusing surface whose area is S. The polar diagram of the source is a circle OAB, whose diameter OA is at right angles to the surface. OA represents the maximum intensity  $I_o$  of the source. The intensity I in any direction

making an angle  $\theta$  with the normal is given by

$$I = I_o \cos \theta$$

The Rousseau diagram is drawn in the usual way, yielding the triangle  $O_1 A_1 A_2$ . The mean spherical candle-power of the source is obtained by dividing the area of the triangle by the diameter of the circle used for constructing the diagram.

$$\therefore \text{m.s.c.p.} = \frac{\text{area } O_1 A_1 A_2}{2 O_1 A_1} = \frac{\frac{1}{2} \times A_1 A_2 \times O_1 A_1}{2 O_1 A_1} = \frac{1}{4} A_1 A_2 = \frac{1}{4} I_o$$

$\therefore$  total flux emitted by the source

$$= 4 \pi \times \text{m.s.c.p.}$$

$$= 4 \pi \times \frac{1}{4} I_o$$

$$= \pi I_o \text{ lumens}$$

Let the brightness of the source be B candles per unit area,

$$\text{then } I_o = BS$$

$$\text{and total flux} = \pi BS \text{ lumens}$$

$\therefore$  flux emitted per unit area =  $\pi B$  lumens

### Tubular Sources

Let a = radius of cylinder

l = length of finite source

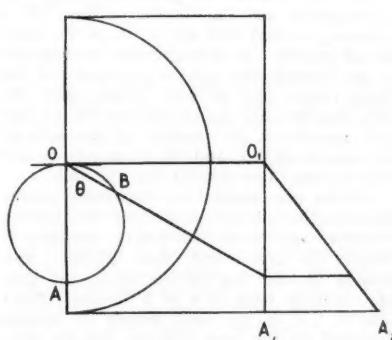


Fig. 1.

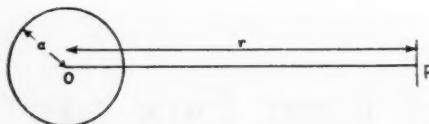
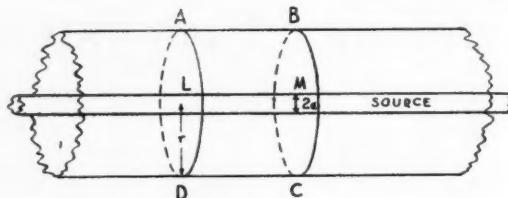


Fig. 2.

Fig. 3.



2a

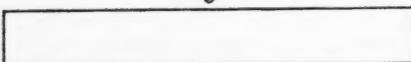


Fig. 4

$I_o$  = maximum intensity of finite source

$i$  = intensity per unit length at right angles to its length

$B$  = brightness of source

#### (1) Finite source.

$$\begin{aligned} I_o &= B \times \text{apparent area} \\ &= B \times 2al \end{aligned}$$

$$\begin{aligned} \therefore \text{total flux emitted} &= \pi B \times \text{curved surface area} \\ &= \pi B \times 2\pi al \\ &= \underline{\underline{\pi^2 I_o \text{ lumens}}} \end{aligned}$$

#### (2) Infinite source.

As the source is infinitely long, the illumination on the inside surface of a cylinder co-axial with the source is the same at all points. If this cylinder is assumed to be divided into smaller cylinders, of the same radius and of unit length, then the total flux through the curved surface of each unit cylinder is the product of the area of the curved surface and the illumination, and will be the same for all the cylinders.

All the flux emitted by the source passes through the curved surface of the infinite cylinder, and so if the source radiates  $F$  lumens per unit length, then the total flux passing through the curved surface of each unit cylinder must also be  $F$  lumens. Note that if  $LM$  is the unit length of source enclosed by the unit cylinder  $ABCD$ , then only a portion of the flux  $F$  emitted by  $LM$

actually passes through the curved surface of  $ABCD$ . The balance of the flux through this curved surface comes from the infinite source outside  $LM$ .

Let  $r$  be the radius of the cylinder co-axial with the source, and  $E$  the illumination on its inner surface. Then

$$F = 2\pi r E$$

$$\text{But } F = \pi B \times 2\pi a$$

$$\therefore 2\pi r E = \pi B \times 2\pi a$$

$$\therefore E = \frac{\pi Ba}{r}$$

$$\text{But } i = B \times \text{apparent area} \\ = B \times 2a \times 1$$

$$\therefore E = \frac{\pi i}{2r} \text{ lumens per unit area}$$

#### Infinite plane source.

Because the source is infinite in extent, then planes parallel to the source are planes of equal illumination.

Consider any infinite plane  $A$  parallel to the source. All the flux emitted by the source must pass through this plane. Hence the total flux through unit area of  $A$  must equal the flux emitted by unit area of the source.

If  $B$  candles per unit area is the brightness of the source, then the flux emitted per unit area is  $\pi B$  lumens.

Hence illumination at any point on  $A$

$$\begin{aligned} &= \text{flux passing through unit area} \\ &= \pi B \text{ lumens per unit area} \end{aligned}$$

This shows that the illumination on a

plane parallel to the source is independent of its distance from the source.

#### Spherical source.

Let O be the centre of the spherical source, which is of radius  $a$ . To find the illumination E on a surface at P, perpendicular to OP.

The total flux passing through the imaginary sphere centred at O and of radius OP ( $= r$ ) must equal the output of the source.

$$\therefore 4\pi r^2 E = 4\pi a^2 F$$

where F is the flux emitted per unit area of the source. If B is the source brightness,

$$F = \pi B$$

$$\therefore E = \frac{a^2 F}{r^2} = \frac{a^2 \pi B}{r^2}$$

$$= \frac{I}{r^2}$$

where I is the intensity of the source as measured at a point whose distance from the source is large compared with  $a$ . From this point the apparent area of the source is  $\pi a^2$ , and hence  $I = \pi a^2 B$ .

This result shows that the spherical source acts as though it was a point source of intensity I situated at its centre.

## SITUATION VACANT

TECHNICAL WRITER required by large electrical manufacturers (E.L.M.A. Member). Central London Office. To write lucid technical sales material all types lamps and lighting. Ample source information available. Higher Nat. Cert. E.E. or equivalent with lamp and lighting experience. I.E.S. member preferred. Company pension scheme. Permanency for British National, 30-35. Please give full details with example of work, stating salary expected, to Box 809.

## SITUATION WANTED

CANADIAN B.A.Sc., University of Toronto, in Engineering Physics, with enthusiastic interest and extensive training in photometry and illumination design, seeks position in illuminating engineering field.—Box E.

## Correspondence

#### Lighting Terms

To the Editor of LIGHT AND LIGHTING

Sir.—I think your readers might be interested to know of a new term—new to me, anyway—in regard to the introduction of emergency lighting in buildings.

Obviously emergency lighting must have some reconciliation with the level of normal lighting, and we have been informed that careful consideration must be given to the "Lux Shock" likely to be encountered by the public.

This kind of pseudo-technical nonsense makes me extremely irritated, and I do hope it will be discouraged, or we shall soon find ourselves surrounded by the equivalent of the R.A.F. slang, which, whilst being both interesting and amusing, is not quite the kind of thing desirable in the business of lighting.—Yours, etc.,

J. MORTIMER HAWKINS.

## New Lighting Trade Association

The formation of a new association of lighting equipment manufacturers is announced. It is entitled "The National Association of Manufacturers of Electric Lighting and Allied Equipment," and will include members from various branches of the lighting industry, including manufacturers of incandescent and fluorescent fittings, lighting auxiliaries, and control gear. The membership at present includes Berry's Electric, Ltd., Dernier and Hamlyn, Ltd., Ecko-Ensign Electric, Ltd., Hailwood and Ackroyd, Ltd., Herman Smith, Ltd., Frederick Thomas and Co., Ltd., and Thorn Electrical Industries, Ltd. The association is intended to encourage the maintenance of approved trading terms by contractors and traders, and to maintain standards of quality, etc.

## Fluorescent Lighting in Schools

The E.L.M.A. Lighting Service Bureau has recently issued a booklet or "memorandum" on this subject, in which the effect of fluorescent lighting on the vision and environment of schoolchildren and the economics of this form of lighting in schools are discussed. According to the preface to this booklet, there is a tendency these days to attempt to reduce rising costs of building by reduction on lighting costs at the expense of lighting effectiveness. Such attempts at false economy in connection with schools should be most strongly opposed. Copies of the booklet may be obtained free from the Lighting Service Bureau, 2, Savoy Hill, W.C.2.

## Courses in Illuminating Engineering

Courses for the City and Guilds Certificates in Illuminating Engineering which have been arranged for the coming session are as follows:—

### London

*Borough Polytechnic (Borough High Street, S.E.1).*

A course for the Final Certificate (Section "A") will be held on Tuesdays and Fridays from 6.30-9.30 p.m. The course for Section "B" will be held on Mondays from 2-4.30 p.m. and from 5.30-8 p.m.

The Intermediate Course will be held on Thursdays from 2-4.30 p.m. and from 5.30-8 p.m.

Classes will commence on September 25.  
*Northampton Polytechnic (St. John Street, E.C.1).*

Part-time day and evening courses:—

Intermediate Course will be held on Wednesdays from 2-5 p.m. and from 6-8.30 p.m., and the Final Course (Section "B") on Thursdays from 2-5 p.m. and from 6-8.30 p.m.

### Evening Courses:—

Intermediate Course on Mondays from 7-9.30 p.m., and on Wednesdays from 6-8.30 p.m. Final Course (Section "B") on Tuesdays from 7-9.30 p.m. and on Thursdays from 6-8.30 p.m.

An additional evening for Mathematics will be arranged if required. Classes will commence on September 25.

### Cardiff

*Cardiff Technical College (Cathays Park, Cardiff).*

Arrangements are being made for courses for both the Intermediate and Final examinations. The Intermediate Course will cover the syllabus in two years, and classes will be held on Monday afternoons and evenings. The part-time evening classes for the Final Course will take two years and will be held on Friday evenings.

Further particulars may be obtained from Mr. W. A. Cooper, Secretary of the Cardiff Centre, or from Dr. Somerville Vernon, Physics Department, Technical College, Cathays Park, Cardiff.

### Liverpool

*Bootle Technical College (Balliol Road, Bootle, Liverpool, 20).*

Evening Courses are being held for the Intermediate and Final examination, and further particulars may be obtained from J. Cormack, Esq., Principal of the College.

### Glasgow

*Stow College (43, Shamrock Street, C.4).*

Evening Courses for the Intermediate

examinations will be held on Tuesdays and Thursdays from 7.30-9.30 p.m. Further particulars may be obtained from the Director of Education, Education Offices, 129, Bath Street, Glasgow, C.2.

### Leeds

*Leeds College of Technology (Cookridge Street, Leeds, 2).*

A part-time day course for Sections "A" and "B" of the Final Grade examination has been arranged. The classes will be held on one half day and one evening per week. If there are sufficient enrolments a course will be held to prepare students for the Intermediate examination. Further information may be obtained from Dr. E. Walton, Head of the Electrical Engineering and Physics Department.

### Correspondence Courses

For those unable to attend the above classes we understand that correspondence courses for both the Intermediate and Final examinations are conducted by the British Institute of Engineering Technology, 17-19, Stratford Place, London, W.1, from whom full details can be obtained.

## City and Guilds Examination Results

The results of the City and Guilds of London Institute examinations in illuminating engineering, which were held last May, have just been announced and are given below:—

### INTERMEDIATE GRADE

#### LONDON:

*First Class.*—Bird, R. T. H.; Collier, B. D.; Cooper, L. P.; Dickinson, A. J.; Evans, K. M.; Fothergill, A. E.; Hart, J. S.; Holmes, R. R.; Johnson, K. G.; Pritchard, D. C.; Robinson, G.; Turbin, A. H. *Second Class.*—Cooke, D. H.; Gale, D. B.; Gorman, S. G.; Lockhart, C.; Newnham, G.; Parker, P. D.

#### GLASGOW:

*First Class.*—Davidson, J. S.; Miller, H. G. M. *Second Class.*—Drummond, J. S.; Hutchison, A.; McKellar, D. C.

#### MANCHESTER:

*Second Class.*—Axon, E.; Jones, H.

#### LEEDS:

*First Class.*—Griffiths, D. R.; Maun, D.; Winsby, R. *Second Class.*—Walker, E.; Bromley, K. A.; Bolser, M.; Polden, F. S.

#### RUGBY:

*Second Class.*—Aikman, J. A.; Wigg, R. W.

#### OTHER CENTRES:

*First Class.*—Aitken, N. H.; France, R. W.; O'Neill, G. H. *Second Class.*—Axon, E.; Bailey, W. C.; Bicket, J. H.; Black, C. Mc.;

Coates, W. C.; Gurney, T. H.; Hyde, A. D.; Jones, D. A.; Jones, H.; Main, J. W.

#### FINAL GRADE

##### SECTION "A"

**LONDON:**  
*First Class*.—Roberts, T.; Scarr, J. R.  
*Second Class*.—Hazel, H.

**CARDIFF:**  
*Second Class*.—Houston, N. D.

**GLASGOW:**  
*Second Class*.—Frame, A. A. G.

**LEEDS:**  
*First Class*.—Addison, S.; Wilcock, A.  
*Second Class*.—Milner, E.; Pullan, W. E.; Temple, A. R.; Walshaw, J. V.

**MANCHESTER:**  
*Second Class*.—Merritt, P. G.

##### SECTION "B"

**LONDON:**  
*First Class*.—Jackson, M. G. A.; Taylor, E. P. *Second Class*.—Algar, P. H.; Bessant,

J. W.; Hazel, H.; Phillips, C. McN.; Thomas, P. A. T.

#### LEEDS:

*First Class*.—Wilcock, A. *Second Class*.—Addison, S.; Hobbs, P. J.; Sessions, H.; Temple, A. R.; Walshaw, J. V.

#### RUGBY:

*First Class*.—Bellchamber, H. E.; Lambert, G. K. *Second Class*.—Phillipson, S. M.

#### MANCHESTER:

*First Class*.—McCauley, J. L.; Merritt, P. G.

#### CARDIFF:

*Second Class*.—Houston, N. D.; Cooper, W. A.

#### SHREFFIELD:

*First Class*.—Marshall, K.

#### GLASGOW:

*Second Class*.—Frame, A. A. G.

#### OTHER CENTRES:

*First Class*.—Haywood, K.; Smith, T. D. *Second Class*.—Dines, R. W. D.; Lockwood, M. G.

## Forthcoming I.E.S. Meetings

### LONDON

#### October 10th

Sessional Meeting. Presidential Address by L. J. Davies. (At the Royal Society of Arts, John Adam Street, W.C.2.) 6 p.m.

#### November 14th

Sessional Meeting. "The Lighting of the House of Commons," by C. Dykes-Brown. (At the Lighting Service Bureau, 2, Savoy Hill, W.C.2.) 6 p.m.

### CENTRES AND GROUPS

#### September 28th

"Cold Cathode Lighting Equipment," by E. A. Langsdon. (At the Yorkshire Electricity Board, 45-53, Sunbridge Road, Bradford.) 7.30 p.m.

#### September 28th

Visit to Demonstration Theatre. (At W. J. Furse & Co., Ltd., Nottingham.)

#### October 2nd

Chairman's Address by J. A. Whittaker. (At the Medical Library, The University, Weston Bank, Sheffield, 10.) 6 p.m.

#### October 4th

Chairman's Address by J. S. McCulloch. (At the Minor Durrant Hall, Oxford Street, Newcastle-on-Tyne, 1.) 6.15 p.m.

#### October 4th

"Church and Chapel Lighting," by L. C. Rettig. (At 4, Northampton Gardens, Swansea.) 5.45 p.m.

#### October 5th

"Church and Chapel Lighting," by L. C. Rettig. (At the South Wales Electricity Board, Demonstration Theatre, The Hayes, Cardiff.) 5.45 p.m.

#### October 5th

"Modern Methods of Illumination," by C. W. Rawlings. (At the Agricultural House, Queen Street, Exeter.) 7 p.m.

#### October 6th

"Light, Colour and the Stage," by E. E. Faraday. (At the Provident Hall, Prewett Street, Bristol.) 7 p.m.

#### October 6th

Chairman's Address by F. Penson. (At the Imperial Hotel, Temple Street, Birmingham.) 6 p.m.

#### October 6th

Chairman's Address by J. W. Howell. (At the Guildford Hotel, The Headrow, Leeds, 1.)

#### October 6th

"Fluorescent Lighting in the Hospital," by J. K. Frisby. (At the Electricity Showrooms, Market Street, Huddersfield.) 7.15 p.m.

#### October 10th

Chairman's Address by T. D. Woods. (At the Temple, 24, Dale Street, Liverpool.) 6 p.m.

#### October 10th

"Floodlighting," by M. W. Pearce. (At 31, Kingsway, Stoke-on-Trent.) 6 p.m.

#### October 11th

"Coloured and Directional Light as Applied to the Stage," by L. G. Applebee. (At the Welfare Club Hall of the City of Edinburgh Lighting and Cleansing Department, High Street, Edinburgh.) 7 p.m.

#### October 12th

"Coloured and Directional Light as Applied to the Stage," by L. G. Applebee. (At the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.) 6 p.m.

#### October 12th

Presidential Address, by L. J. Davies. (At the Demonstration Theatre, East Midlands Electricity Board, Leicester Sub-Area, Charles Street, Leicester.) 6.30 p.m.

#### October 12th

"Recent Advances in Ophthalmology," by D. L. Charters. (Joint Meeting with the British Optical Association.) (At the Demonstration Theatre, Manchester Town Hall Extension.) 6 p.m.

#### October 18th

"Lighting and the Visual Art of Play Production," by P. Corry. (At the Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough.)

#### October 19th

Manchester Centre Visit to Siemens Lamp Works, Preston.

#### October 26th

"Rare Gas Lamps—The Gas Arc," by H. W. Cummings. (At the Gas Showrooms, Parliament Street, Nottingham.) 5.30 p.m.

#### October 26th

"Industrial Seeing," by W. Imrie-Smith. (At the Yorkshire Electricity Board, 45-53, Sunbridge Road, Bradford.) 7.30 p.m.

#### November 1st

"The Problems Associated with Underground Lighting in British Coal Mines," by D. A. Strachan. (At the Minor Durrant Hall, Oxford Street, Newcastle-on-Tyne, 1.) 6.15 p.m.

#### November 1st

Film Evening. (At 4, Northampton Gardens, Swansea.) 5.45 p.m.

## POSTSCRIPT

By "Lumeritas"

Modern street lighting equipment has been the subject of several recent letters to "The Times." The first of these referred to "the present craze for erecting lamp-posts like concrete gibbets with corpse lights dangling off them in old country towns." The writer complained that "the columns are too thick, the colour and texture too drab and hard ever to go with a delicate brick and plaster background of Georgian and earlier houses. Seen against the beautiful building stone of Wiltshire and Somerset, as in Chippenham and Crewkerne, they are painfully out of place. They are usually out of scale too, towering with graceless outline above the old roofs. They form frightful frames to Salisbury Cathedral and the city of Winchester." Some of these concrete lamp standards have—as the writer remarked—been passed by the Royal Fine Art Commission, but this does not mean that they can be erected anywhere without being incongruous and offensive to the beholder.

In a subsequent letter, Lord Crawford pointed out that in passing designs for lamp-posts and other street furniture the Royal Fine Art Commission is often in the unfortunate position of having to select the least offensive; and the chairman of the commission, while believing that the advice given by this body has resulted in the production of lamp-posts of a much superior type to what would have been produced without it, rightly pointed out that upon the authorities who put up lamp-posts rests the responsibility of selecting designs which are suitable for particular environments. No doubt the street lighting engineer is primarily concerned to meet lighting requirements but, since most of our towns will long continue, architecturally, to be not in the modern mode, I hope he will do his best to give us modern standards of street lighting without structural misfits.

Film studio lighting as a possible cause of injury to eyesight has been under consideration by a Home Office Departmental Committee on the Employment of Children as film actors, in theatrical work and in ballet whose report (Cmd. 8005) was published by H.M.S.O. last month. The committee regarded this matter as of fundamental importance, and anxiety was aroused in their minds partly by a clause included in the

agreement (Baby Contract) prescribed for the employment of children under six months in Hollywood studios. This clause is to the effect that the film producing company signs the agreement "with full knowledge that serious eye injury has been known to follow the exposure to bright light of the immature eyes of infants." Although most witnesses who gave evidence to the committee made the point that steps must be taken to safeguard the eyes of children appearing in films, it emerged that their opinion was based on an assumption that the lights must be prejudicial to the eyes of children and for this they could produce no scientific backing. The committee took expert medical and technical advice, but obtained no evidence of injury to eyesight, except that cases have been known of temporary irritation of the eyes of adult actors in films which might have been due to exposure to ultra-violet rays. The committee concluded that "even though film studios now commonly used enclosed lights which reduce risk, nevertheless, in opening up the door to the employment of children in films it would be well to proceed with the greatest caution because of the risk of damage to eyesight and the possibility of technical changes which may involve greater intensity of light." They recommend that the medical examination of children prior to employment should include an examination of the eyes, and that there should be a maximum to the period of exposure under the camera at any one time. For children under six months this maximum exposure should be 30 seconds; it should be 60 seconds for children over that age, but under two years, and two minutes for children over two, but under seven years of age. Despite the lack of evidence that film studio lighting as now practised is injurious to the eyes of artists, I think the committee has been wise to make these recommendations.

As long ago as 1921 a departmental committee on the Causes and Prevention of Blindness, of which Sir John H. Parsons was a member, issued an interim report regarding alleged dangerous lights in Kinema Studios, and found that "suitably enclosed and screened arclights are not likely to be dangerous apart from culpable temerity on the part of the artistes."

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